MINING engineering

MARCH 1958

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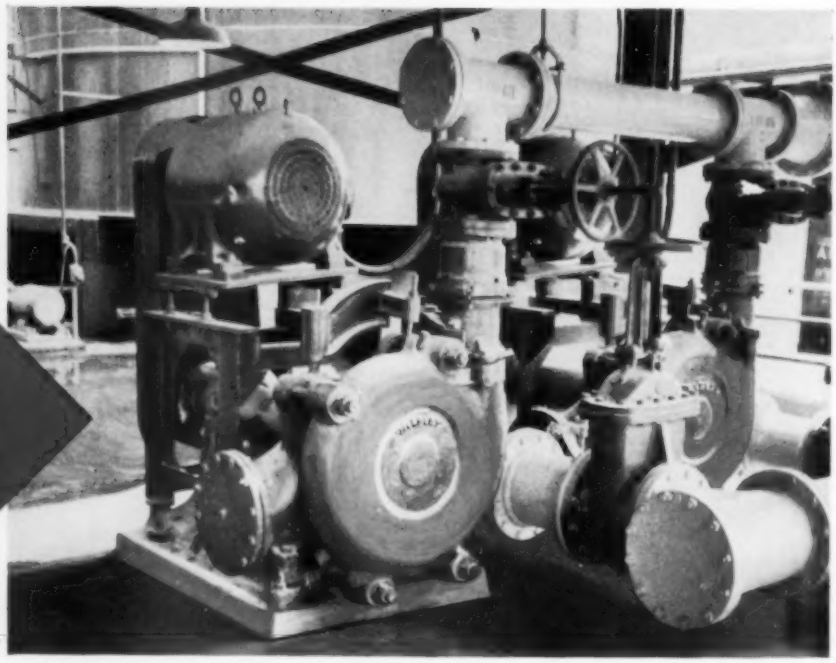

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Coming Events

Mar. 20, Utah Section, speaker: L. L. Newman; subject: *Mechanization of the Soviet Peat Industry;* Newhouse Hotel, Salt Lake City.

Mar. 27-29, AIME Pacific Southwest Mineral Industry Conference, St. Francis Hotel, San Francisco.

Apr. 9, AIME San Francisco Section, speaker: Ed Hassan; subject: *Kaiser Aluminum;* Engineers' Club, San Francisco.

Apr. 11, AIME Reno Subsection, 12 noon, Nevada Room, Hotel Mapes, Reno, Nev.

Apr. 14-16, Lead Industries Assn., Chase-Park Plaza Hotels, St. Louis.

Apr. 14-15, American Zinc Inst., Chase-Park Plaza Hotels, St. Louis.

Apr. 17-19, AIME Pacific Northwest Regional Conference, Spokane.

Apr. 18-20, AIME Alaska, Southwest Alaska Sections, mining and minerals conference, School of Mines, University of Alaska, College, Alaska.

Apr. 21-22, Inst. on Lake Superior Geology, University of Minnesota, Duluth Branch, Duluth.

Apr. 25, AIME Pennsylvania-Anthracite Section, spring technical meeting, Hazleton, Pa.

May 5-7, American Mining Congress Coal Convention, Netherland Hilton Hotel, Cincinnati.

May 9-10, Dept. of Mining Engineering, Montana School of Mines and AIME, Mining Assn. of Montana, The Anaconda Co., Montana Soc. of Engineers, symposium on hydraulic emplacement of mine stope fill, Montana School of Mines, Butte, Mont.

May 9-11, AIME Uranium Section, Third Annual Uranium Symposium, Moab, Utah.

May 22-23, 34th annual conference, Lake Superior Mine Safety Council, Hotel Duluth, Duluth.

May 24, AIME Colorado MBD Subsection, Broadmoor Hotel, Colorado Springs, Colo.

June 26, AIME Pennsylvania-Anthracite Section, summer meeting, Split Rock Lodge, White Haven, Pa.

Sept. 17-19, AIME Rocky Mountain Minerals Conference, Newhouse Hotel, Salt Lake City.

Sept. 22-25, American Mining Congress Mining Show, Civic Auditorium, San Francisco.

Oct. 9-10, AIME-ASME Solid Fuels Conference, Hotel Chamberlin, Old Point Comfort, Virginia.

Oct. 23-25, AIME Mid-America Minerals Conference, Chase-Park Plaza Hotels, St. Louis.

Feb. 15-19, 1959, AIME Annual Meeting, San Francisco.

MINING engineering

VOL. 10 NO. 3 MARCH 1958

COVER

Artist Herb McClure's charcoal sketch of Stan Michaelson signals start of the second year for the Society of Mining Engineers. For an introduction to your new President and other Society officers turn to the SME Bulletin Board, page 381.

SME PRESIDENT 1958

Biography of Stanley D. Michaelson 382

ARTICLES

El Salvador Reports on Inca Adit Progress — H. E. Robbins, T. H. Dudley, and E. A. Lucero 333

Automation in the Mineral Industries — J. McCaslin 337

A Program for the Mining Industry — R. M. Foose 342

Improved Pilot Hole Method for Shaft Extension — R. Lee-Aston 346

Manufactured Sands Successfully Used in Grouts — J. M. Polatty 352

Agglomeration: Four Methods

The Traveling Grate—Updraft — D. C. Violetta 354

The Traveling Grate—Downdraft — Alan English and M. F. Morgan 357

The Traveling Grate—Updraft/Downdraft — K. J. E. Meyer and Hans Rausch 359

The Shaft Furnace — F. D. DeVaney 361

TRANSACTIONS

Structural Control of Contact Metasomatic Deposits in the Peruvian Cordillera — A. J. Terrones L. 365

Relation of Magnetic Susceptibility to Mineral Composition — E. M. Spokes and D. R. Mitchell 373

Discussion 379

FEATURES

Personnel	300	AIME News	385
Books	302	Around the Sections	389
Manufacturers News	311	Personals	393
Reporter	315	SME Preprint List	398
Mining News	318	Obituaries	409
Trends	321	Professional Services	412
SME Bulletin Board	381	Advertisers Index	416

Drift: The Porphyry Coppers—A Milestone — R. A. Beals 327

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Mining Executive or Consultant, B.S. in mining engineering, M.S. in geological engineering, age 46. Fifteen years experience exploration and exploitation. Specialties: 1) exploration and 2) ability to increase efficiency small to medium-scale operations in Latin America. Desires affiliation with progressive company or consulting group. Fluent Spanish. Registered engineer. Available 60 days. M-390.

Mine Manager or Superintendent, B.S., age 39. Thirteen years in open pit and underground operations. Familiar with mine administration, exploration, development, and production. Fluent Spanish and French. Will travel. Prefer foreign location. M-392.

Economic Geologist, Ph.D., age 45. Twenty years background in mineral exploration, property evaluation, and mine development; eight years in charge of major programs. Desires work of a similar nature on long-term program. M-393.

Geologist-Mineral Economist, M.Sc., 34, single. Twelve years experience exploration-operational work Latin American and U. S. Desire permanent responsible position in operating or administrative field. Will locate anywhere. M-394.

Mining Geologist, B.S. and M.S. in geological engineering, age 30. Two and one half years experience mineral reconnaissance and property evaluation work in Pacific northwest and in exploration and development of nonferrous metallic and nonmetallic, including uranium, mineral deposits of various types in Montana. Prefer foreign or western U. S. M-395.

Superintendent of Mine Operations, age 44, practical knowledge. Seventeen years foreman, superintendent, and general manager in mining and milling and highway construction. Six years as driller in mines; two years as trackman; two years underground safety man. Prefer midwest or west. M-396.

Geologist, doctor of science; age 29. Eight years experience various phases of geology, especially exploration and mining geology; three years experience mining and engineering. Includes two years foreign. Speak Portuguese. Will consider any location. M-397.

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(Continued on page 306)

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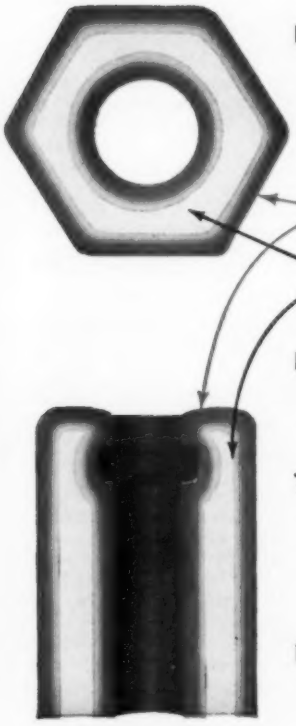
Cuts drilling costs . . . reduces steel breakage



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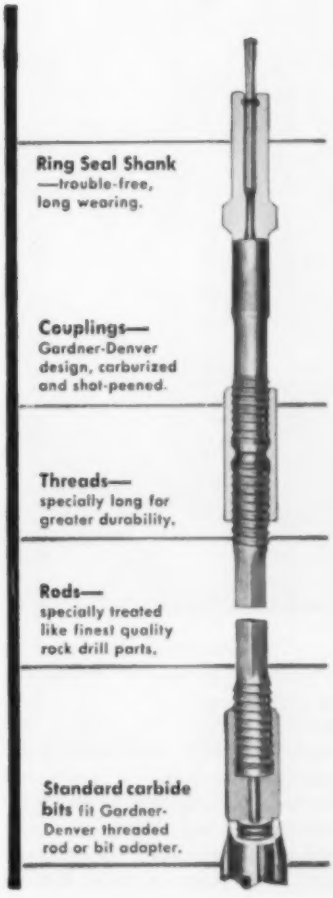
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	CL5-200 Series	CL5-400 Series	CL5-600 Series	CL5-700 Series	CL5-1000 Series
Thread Size	1 1/16"	1 1/4"	1 1/2"	1 3/4"	2 1/2"
Recommended Drill Size	3" and smaller	4" and smaller	4" and 4 1/2"	4" and 4 1/2"	5 1/2"
Recommended Bit Size	1 5/8" to 1 7/8"	2" to 2 1/4"	2 3/8" to 2 3/4"	3" to 4"	4", 4 1/2" and 5"
Rod Sizes	7/8" Hex.	1" Hex.	1 1/4" Hex.	1 1/4" and 1 1/2" Hex.	1 7/8" Hex.
Rod Lengths	2' to 20'	2' to 20'	2' to 20'	2' to 20'	4' to 20'
Coupling Diameter	1 7/16"	1 3/4"	2 1/8"	2 1/2"	3 3/8"
Ring Seal Shank	1" Hex. Collared 1 1/4" Rd. Lugged	1 1/4" Rd. Lugged 1 1/2" Rd. Lugged	1 1/4" Rd. Lugged 1 1/2" Rd. Lugged	1 1/2" Round	2 1/2" Round

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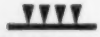

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BOOKS

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Coal in Southern Africa, by Edna P. Plumstead, *Witwatersrand University Press,* Milner Park, Johannesburg, South Africa, illus. and map, approximately $11.25, 1957. Discusses coal as a rock; biogeographical and dynamochemical stages of coal formation; bearing of physical properties on classification, utilization, and ash of coals; distribution of coal in southern Africa; and useful coal statistics of the Union of South Africa.

Symposium on Radiation Effects on Materials, Special Technical Publication 208, *American Soc. for Testing Materials,* 1916 Race St., Philadelphia 3, Pa., 196 pp., $4.75, 1957.—This symposium is the first of a series sponsored jointly by ASTM and the Atomic Industrial Forum, presented at the Second Pacific National Area Meeting, Los Angeles, September 1956. It is divided into three parts: 1) theory of radiation; 2) radiation facilities and mechanics of testing; and 3) experimental tests and results on a) fuel and graphite materials and b) structural materials, including organics. The data and evaluations presented are made as a contribution to the understanding of existing code and specification values as they apply to nuclear reactor structures and components. •

Reconnaissance Geology of the Leesburg Quadrangle, Lemhi County, Idaho, Pamphlet No. 113 by Philip N. Shockey, *Idaho Bureau of Mines and Geology,* Moscow, Idaho, 4 pp., $1.25 1957.—This report is the result of work during two field seasons and two winters in the laboratory at Cornell University. The report covers information on stratigraphy, structural geology, sedimentation, geomorphology, economic geology, etc., of the quadrangle. Plates, photos, figures, and a map of the Leesburg Quadrangle illustrate the pamphlet.

Mineral Beneficiation and Extractive Metallurgical Techniques, special issue of the *Indian Mining Journal,* 6/2, Madan St., Calcutta 13, India, over 200 pp., $4.00 including postage, 1957.—This special issue, incorporating the entire proceedings of a recent symposium held at the National Metallurgical Laboratory, India, features 53 technical research and survey papers from eminent scientists and technologists—Indian as well as foreign. Some of the topics discussed are: efficiency of the iron blast furnace, benefication of manganese ores, concentration of Indian chrome ores by ore-dressing methods, electrolytic production of titanium, and cyclone washer for coal cleaning.

Air Spy, by Constance Babington-Smith, *Harper & Brothers,* New York, $4.00, 1957.—The story of photo intelligence in World War II, which laid the basis for present-day aerial survey and geophysics, is now told for the first time by the author, who founded the Aircraft Section of the Central Interpretation Unit of Medmenham in England and directed it until VE-Day. *Air Spy* provides behind-the-scene angles on some of the most important events of the war in Europe: the Bismark chase, the Commando raids, the great Allied bombing offensive, D-Day itself, incredibly accurate forecasts of U-boat and aircraft production, and the analyzing of the German V-weapon threat three months before the first buzz bomb appeared over England. The book is abundantly illustrated with photographs of the material depicted. •

Information Relating to Mineral Exploration and Development on Public Lands, (State of Maine) *Maine Geological Survey,* Dept. of Economic Development, Augusta, Maine, for the Maine Mining Bureau, 35¢, 16 pp., 1957.—This booklet outlines the public mining law enacted this year by the 98th Legislature, describing with diagrams the procedure for prospecting and locating mining claims on state-owned lands. A state map is provided showing the locations of public school lots available for mineral development in the unorganized townships. In general, the revised mining law described by the booklet allows staking of claims upon receipt of a prospector's permit, and recording of the claims in the office of the Forrest Commissioner.

MacRae's Blue Book, 1958 edition, compiled by *MacRae's Blue Book Co.,* 18 E. Huron St., Chicago 11, Ill., $15 plus postage (or postpaid if payment accompanies order), Apr. 1, 1958.—Annual directory containing company listings, product directory, address and trade name sections.

Economics of Atomic Energy, by Mary S. Goldring, *Philosophical Library Inc.,* 15 E. 40th St., New York 16, N. Y., 175 pp., $6, 1957.—A discussion of the growth of nuclear power in Great Britain covering the industry—factories, tools, investment; power—need for, cost, and export market; and investment—British pattern, industry, methods in other countries, and future. •

Tatlock's Four Corners and Rocky Mountains Directory, compiled by

(Continued on page 306)

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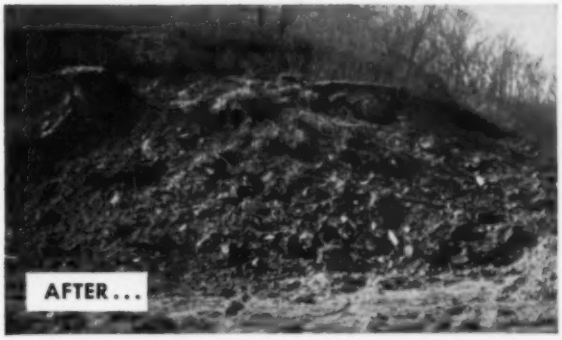

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DEOXIDATION OF STEEL

TABLE OF CONTENTS

		Page
Preface		
Frontispiece		
Charles Holmes Herty, Jr. Biographic Sketch		i
El Al		iv
List of Publications		viii
Acknowledgment		xiii
Chapter I.	The Significance of Herty's Work to Modern Steel Practice by G. R. Fitterer	xv
Chapter II.	Elimination of Metalloids in the Basic Open Hearth Process by J. L. Keats and C. H. Herty, Jr., Trans. AIME, Vol. 73, 1079-1106, 1926	41
Chapter III.	The Solubility of Iron Oxide in Iron by C. H. Herty, Jr., J. M. Gaines, Jr., B. M. Larsen, W. A. Simkins, R. L. (Geruso) Humphrey and S. P. Watkins, Cooperative Bulletin No. 34, Metallurgical Advisory Board*, 68 pages, 1927	71
Chapter IV.	A New Method for Determining Iron Oxide in Liquid Steel by C. H. Herty, Jr., J. M. Gaines, Jr., Hyman Freeman and M. W. Lightner, Trans. AIME, Iron and Steel Division, Tech. Paper 311, 28-38, 1930	143
Chapter V.	Deoxidation with Silicon and the Formation of Ferrous-Silicate Inclusions in Steel by C. H. Herty, Jr., and G. R. Fitterer, Cooperative Bulletin No. 36, Metallurgical Advisory Board, 94 pages, 1928	157
Chapter VI.	Deoxidation with Silicion in the Basic Open Hearth Process by C. H. Herty, Jr., C. F. Christopher and R. W. Stewart, Cooperative Bulletin No. 38, Metallurgical Advisory Board, 172 pages, 1930	255
Chapter VII.	Deoxidation of Steel with Aluminum by C. H. Herty, Jr., G. R. Fitterer and J. M. Byrns, Cooperative Bulletin No. 46, Metallurgical Advisory Board, 45 pages, 1930	429
Chapter VIII.	Deoxidation of Open Hearth Steel with Manganese-Silicon Alloys by C. H. Herty, Jr., C. F. Christopher, M. W. Lightner and Hyman Freeman, Cooperative Bulletin No. 58, Metallurgical Advisory Board, 71 pages, 1932	477
Chapter IX.	The Control of Oxide in the Basic Open Hearth Process by C. F. Christopher, Hyman Freeman and C. H. Herty, Jr., Cooperative Bulletin No. 68, Metallurgical Advisory Board, 128 pages, 1934	553
Chapter X.	The Effect of Deoxidation on the Impact Strength of Carbon Steels at Low Temperatures by C. H. Herty, Jr. and D. L. McBride, Cooperative Bulletin No. 67, Metallurgical Advisory Board, 60 pages, 1934	659

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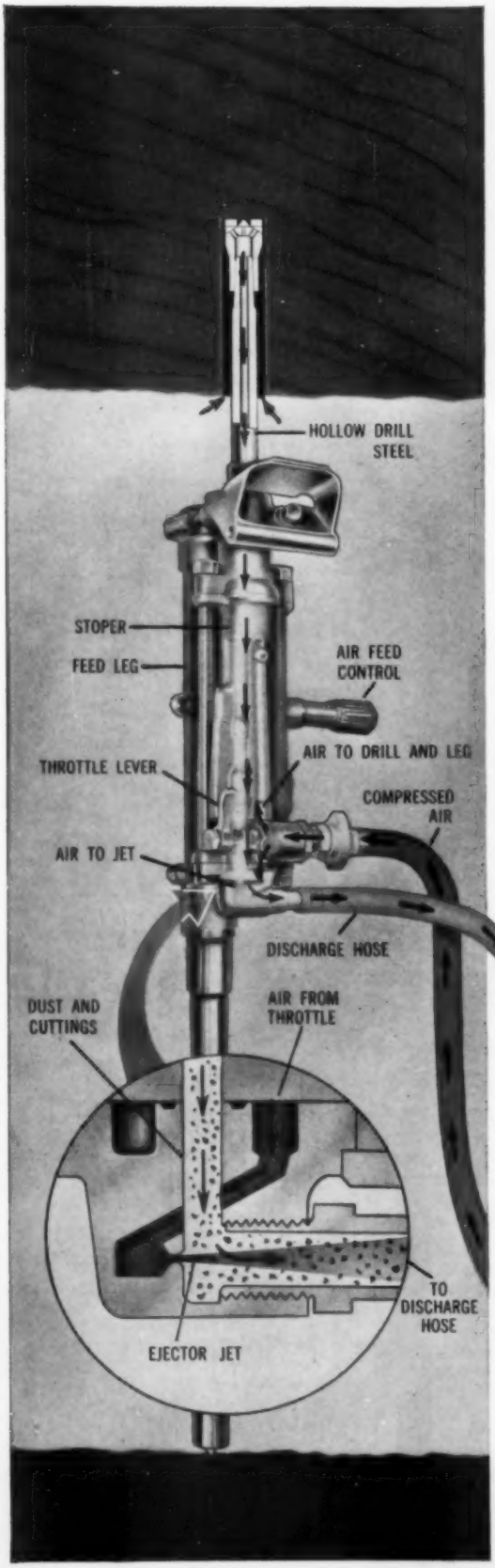

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Books

(*Continued from page 302*)

Tatlock's 608 Majestic Bldg., Denver 2, Colo., 302 pp., $5, 1957.—Petroleum and uranium directory of area. Contains guide to services, list of federal and state agencies, abstractors directory, and general list of concerns and personnel.

The Materials Handling Manual Number 2, compiled by *Boston Publishing Co.*, 795 Boylston St., Boston 16, Mass., 412 pp., $5 U. S. and possessions, $6 elsewhere, 1958.—Covers industrial trucks and tractors; industrial truck attachments; how to select nonpowered floor equipment; conveyors and conveying equipment; cranes, hoists, and monorails; yard handling equipment; how to control packaging costs; ideas for handling, storing, and shipping materials.

1958 Arco Income Tax Guide, by S. Jay Lasser, *Arco Publishing Co.*, 480 Lexington Ave., New York 17, N. Y., 128 pp., $1, 1957.—Prepared specifically for filing 1957 income tax returns, book is a step-by-step guide for filling out tax form; contains information on item savings, tax tips, and record keeping for 1958 returns; a list of tax-saving possibilities; and sample filled-out forms. •

State Publications

An Aeromagnetic and Geologic Reconnaissance Survey of Portions of Hancock and Penobscot Counties, Maine, GP&G Survey No. 1, containing 10 map sheets. Published by *Maine Geological Survey* and available from John F. Rand, State Geologist, Dept. of Economic Development, Room 211, State Office Bldg., Augusta, Me.; $5 prepaid (make check or money order payable to Treasurer of the State of Maine), 1958.

Coal Beds of the Conemaugh Formation in Ohio, by Theodore A. DeBrosse, Report of Investigations No. 34, *Ohio Division of Geological Survey*, Orton Hall, The Ohio State University, Columbus 10, Ohio, 33 pp., maps, 50¢ (plus 2¢ tax in Ohio), 1957.

Subsurface Stratigraphy of the Salem Limestone and Associated Formations in Indiana, by Arthur P. Pinsak, Bulletin No. 11, Publications Section, *Geological Survey*, Indiana Dept. of Conservation, Indiana University, Bloomington, Ind., 62 pp., 5 plates, 8 figs., 2 tables, $2, 1957.

Central Wyoming Phosphate—Rock, Character, Processing, and Economics by Walter E. Duncan and H. G. Fisk, Bulletin No. 6, *Natural Resources Research Inst.*, College of Engineering, The University of Wyoming, Laramie, Wyo., 57 pp., 19 figs., gratis, 1957.

Occurrence of Silurian Salt in New York State, State Museum Bulletin 361, *New York State Museum*, Albany 1, N. Y., bulletin, map, stratigraphic sections, $1.50 (make check or money order payable to New York State Education Dept.), 1957.

Bedrock Geology of the North End of the Tobacco Root Mountains, Madison County, Montana, by Rolland R. Reid, Memoir 36, *Montana Bureau of Mines and Geology*, Room 203-B, Main Hall, Montana School of Mines, Butte, Mont., 24 pp., 8 plates, 6 figs., $1, 1957.

Reconnaissance Geologic Map of Piñonville Thirty-Minute Quadrangle, by Max E. Willard, Geologic Map 3, *State Bureau of Mines and Mineral Resources* and *New Mexico Inst. of Mining & Technology*, Campus Station, Socorro, N. M., 1 map, 50¢, 1957.

Geochemical Prospecting, General Reconnaissance Methods, by Nalin R. Mukherjee and Leo Mark Anthony, *School of Mines, University of Alaska*, College, Alaska, 82 pp., $2, 1957.

Arizona's Natural Resources, *The Arizona Development Board*, 1521 West Jefferson St., Phoenix, Ariz., 48 pp., gratis, 1957.

Pennsylvanian Underclays—Potential Bonding Clays for Use in Foundries, by Haydn H. Murray, Report of Progress No. 11, *Geological Survey*, Indiana Dept. of Conservation, Indiana University, Bloomington, Ind., 26 pp., 50¢, 1957.

Geology of Puertecito Quadrangle, Socorro County, New Mexico, by William H. Tonking, Bulletin 41, *State Bureau of Mines & Mineral Resources* and *New Mexico Inst. of Mining & Technology*, Campus Station, Socorro, N. M., 60 pp., 1 map, $2.50, 1957.

Geology and Mineral Resources of the Beardstown, Glasford, Havana, and Vermont Quadrangles, by Harold R. Wanless, Bulletin 82, *Illinois State Geological Survey*, Urbana, Ill., 233 pp., 7 plates, 66 figs., 6 tables, $1 postpaid, 1957.

Mineral Production in Illinois in 1956, by W. L. Bunch and W. H. Voskuil, Circular 238, *Illinois State Geological Survey*, Urbana, Ill., 36 pp., 6 figs., 17 tables, 3½¢ postage, 1957.

Use of Trace Metals to Identify Illinois Crude Oils, by Paul A. Witherspoon and Kozo Nagashima, Circular 239, *Illinois State Geological Survey*, Urbana, Ill., 16 pp., 4 figs., 5 tables, 3¢ postage, 1957.

Geology of Parker County, Texas, by Leo Hendricks, Publication 5724, *The University of Texas*, Bureau of Economic Geology, Box 8022, Austin 12, Texas, 67 pp., 6 figs., 7 plates, 1 map, $1.50, 1958.

Devonian-Mississippian Transition in Central Texas, by P. E. Cloud, Jr., V. E. Barnes, and W. H. Hass, Report of Investigations No. 31, *The University of Texas*, Bureau of Economic Geology, Box 8022, Austin, Texas, 10 pp., 1 fig., 5 plates, 20¢, 1957, reprinted from *Bulletin*, Geological Soc. of America (vol. 68, No. 7, 1957).

Studies of Cenozoic Geology Along Eastern Margin of Texas High Plains, Armstrong to Howard Counties, by John C. Fyre and A. Byron Leonard, Report of Investigations No. 32, *The University of Texas*, Bureau of Economic Geology, Box 8022, Austin, Texas, 62 pp., 10 figs., 5 plates, $1, 1958.

Pleistocene Equidae of Texas, by J. H. Quinn, Report of Investigations No. 33, *The University of Texas*, Bureau of Economic Geology, Box 8022, Austin, Texas, 51 pp., 1 fig., 7 plates, 10 tables, 75¢, 1957.

The Geology of Wylie Mountains and Vicinity, Culberson and Jeff Davis Counties, Texas, by Hugh Hay-Roe, Geologic Quadrangle Map No. 21, *The University of Texas*, Bureau of Economic Geology, Box 8022, Austin, Texas, 75¢, 1958.

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IC 7778 Coal Supplies and Requirements in Western European and Soviet Bloc Countries, 1955 and 1956.

IC 7779 National Motor Gasoline Survey, Summer 1956.

RI 5350 Investigation of Subbituminous-Coal Beds Near Houston, Westward Extremity of Matanuska Coalfield, Alaska.

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IC 7797 The Use of Nonionic Detergent and Citric Acid for Improving Cleanout Procedures of Water-Input Wells in Secondary Oil-Recovery Projects.

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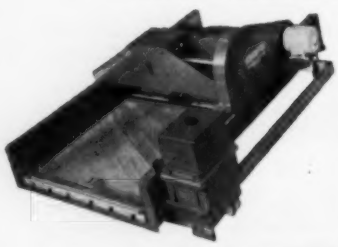

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(*Continued from page 300*)

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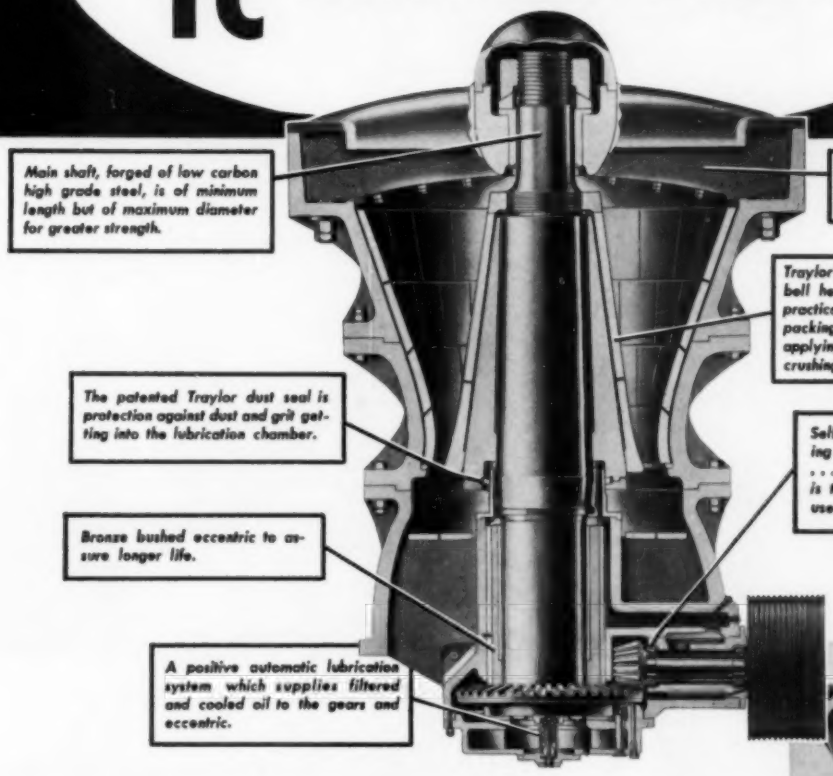

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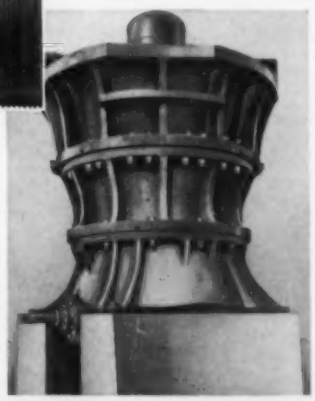

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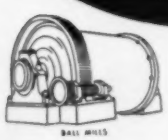

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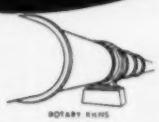

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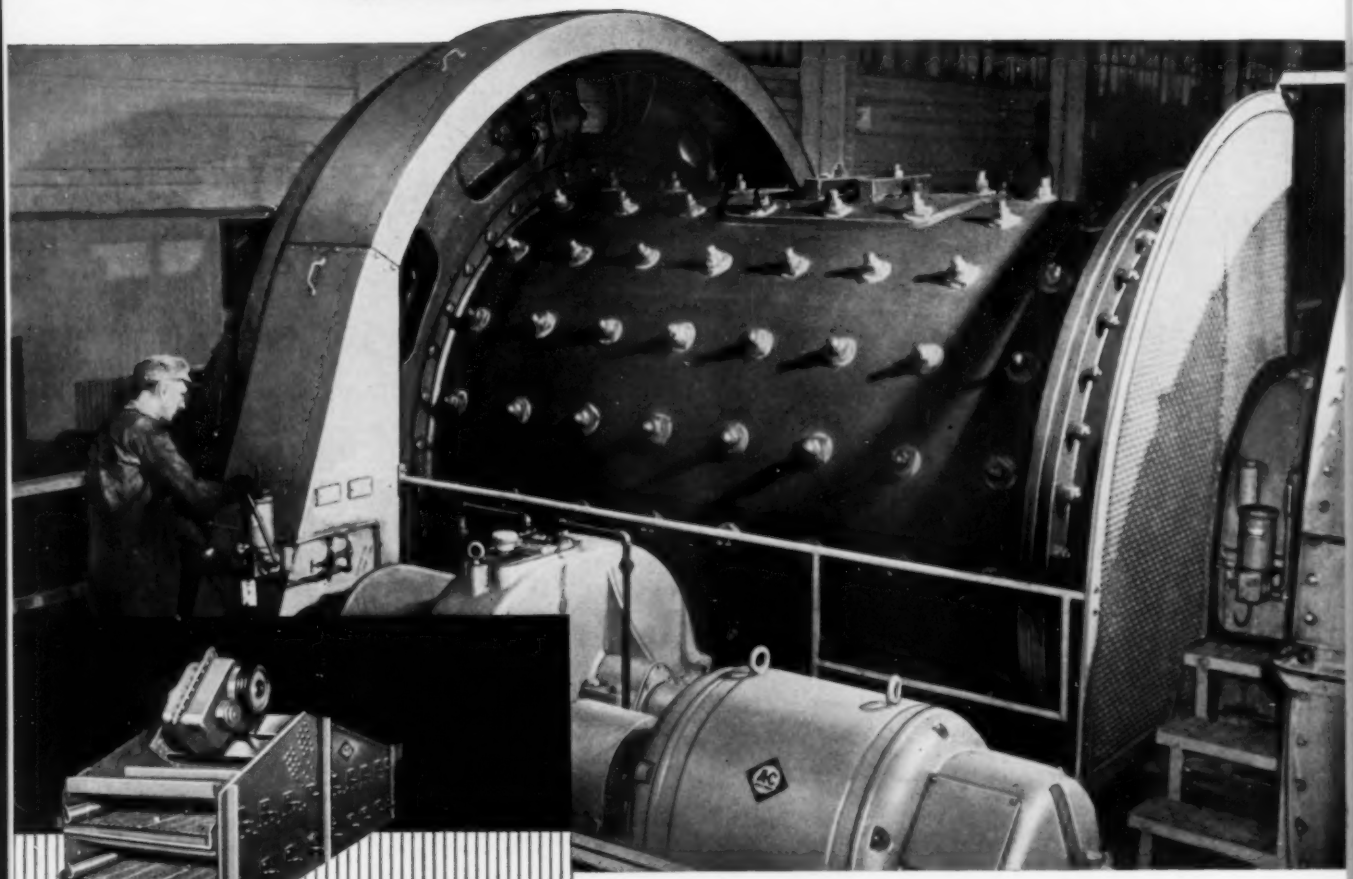

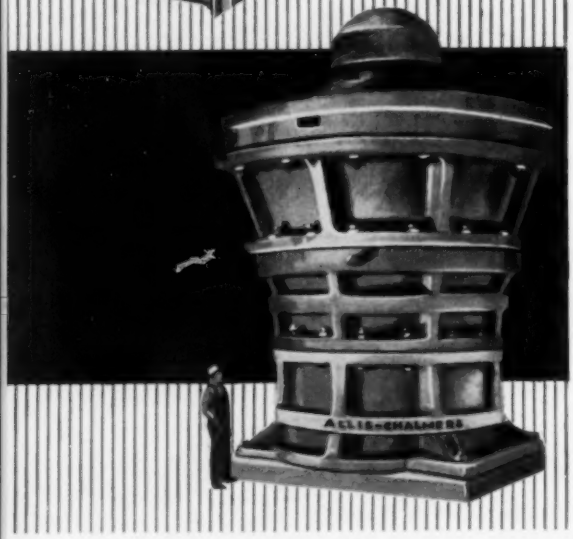

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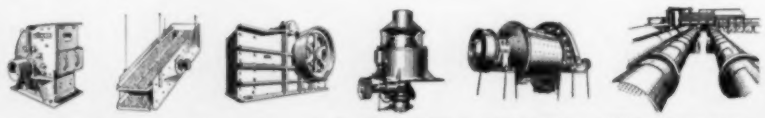

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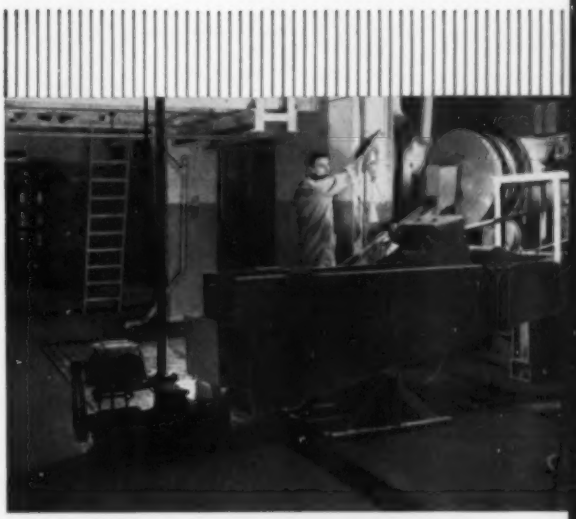

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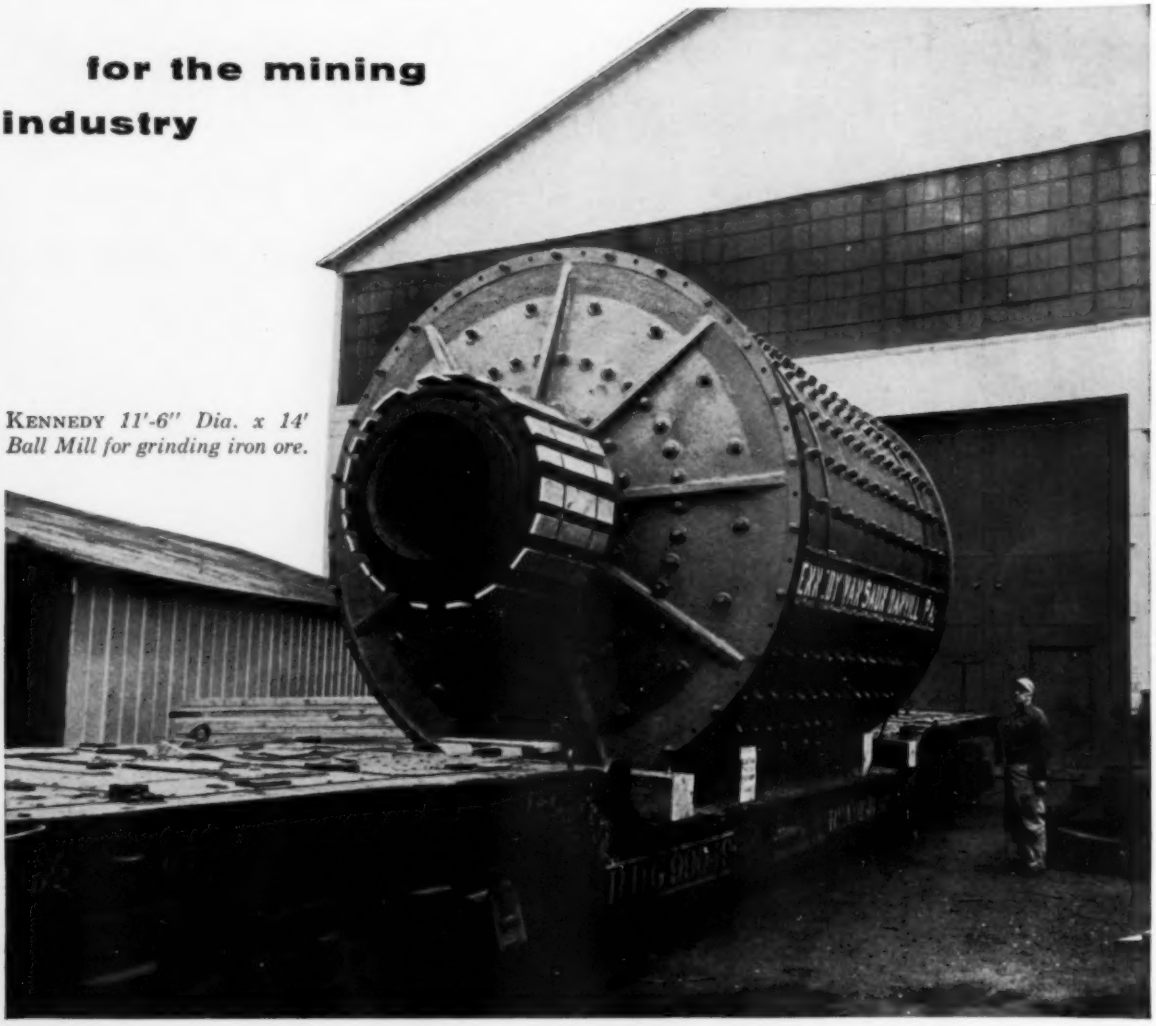

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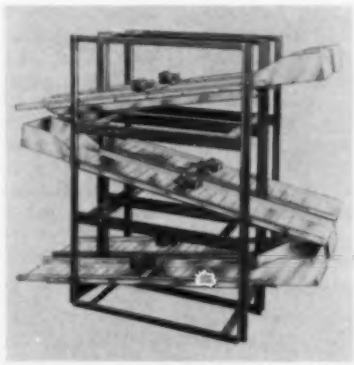

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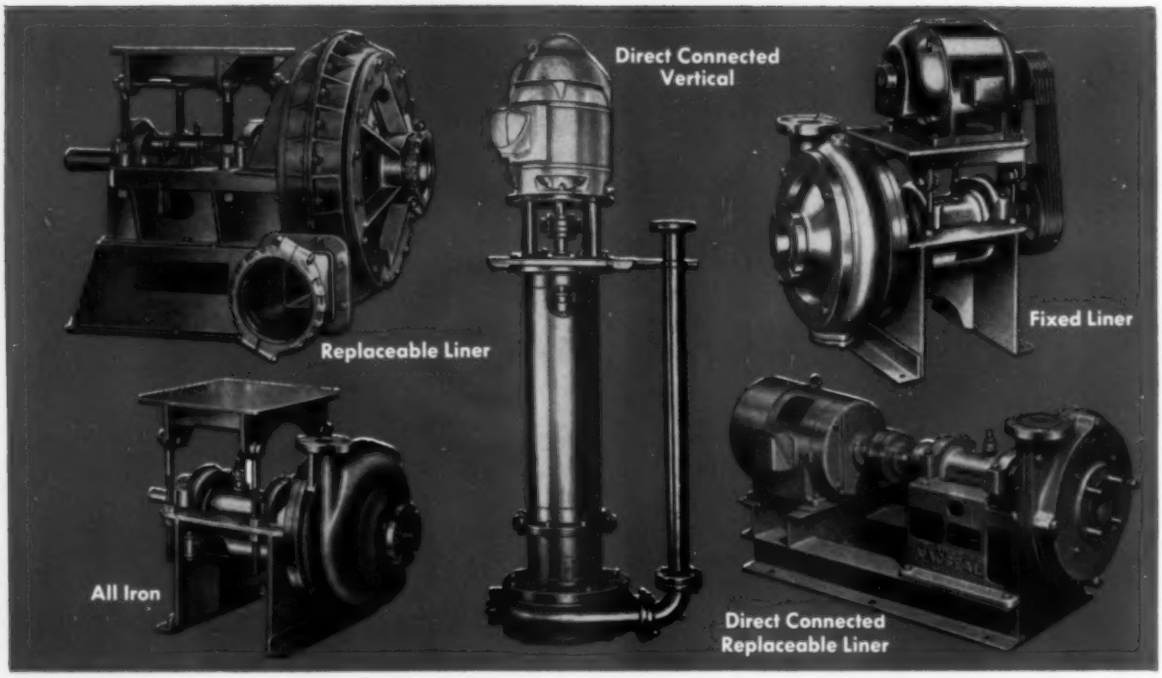

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(21) SAND & DREDGE PUMPS: New 4-page brochure 657 from *Allen-Sherman-Hoff Pump Co.* illustrates a redesigned line of Hydroseal sand and dredge pumps for handling +4-mesh abrasive solids. Shaft and bearings include a patented axial adjustment for proper clearance of working parts. Capacities up to 14,000 gpm.

(22) JAW CRUSHERS: High output, low power, overhead eccentric jaw crushers are described in a new 4-page bulletin from *Kennedy-Van Saun Mfg. & Eng. Corp.* Full details including output and horsepower are given for four models with feed opening sizes from 10x36 in. to 30x42 in.

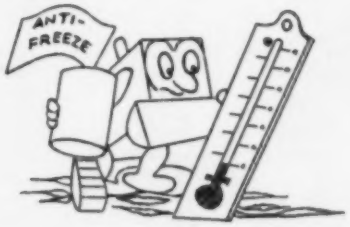
(23) STEEL WEIGHT FINDER: An instrument designed for the steel industry by *Alcott Calculator Co.* enables the user to quickly and accurately determine the exact weights of a variety of steel products. More than 1000 items are covered including angles, beams, channels, flats, rounds, squares, hexagons, and strip. All answers are given exactly as they are shown in standard weight tables—estimating is not needed. The economical finder is 8½ in. in diameter.

(24) SODIUM CHLORATE HANDLING: Because sodium chlorate is increasingly used for uranium ore processing and other applications where an oxidant is needed, *Pennsalt Chemicals Corp.* is offering a bulletin which describes properties and safe handling practices of the agent. Among the information contained are water solubility, product specification, shipping regulations, unloading carriers, dissolving crystals.

(25) BETTER WELDS: A newly-revised edition of "Weldors' Vest Pocket Guide," containing 60 pages of useful arc welding information, is available from *Hobart Bros. Co.* Booklet EW-201 gives tips on solving common welding problems, selecting electrodes, essential procedures.

Free Literature

(26) CAT MAINTENANCE: A 30-page maintenance guide for No. 933, No. 955, and No. 977 Traxcavators has been prepared for operators by *Caterpillar Tractor Co.* The booklet points to improved machine performance and longevity through sound practices and is a supplement to the more detailed data found in Caterpillar "Operation and Maintenance Instructions."



(27) TWIN-POWER SCRAPER: A 24-page catalog from *Euclid Div.*, General Motors Corp., features the model TS-24 Euclid Twin scraper. The catalog, Form 554, covers all features of design, operation, and performance. TS-24's two engines, 300 hp in the tractor and 218 hp at the scraper axle, have separate torque converters and semiautomatic transmissions.

(28) SHOVEL CRANE: *Thew Shovel Co.* points to features of a new self-propelled shovel crane, model SP-107, in a 16-page catalog. The short-couple, square design of the rubber-tired carrier with four-wheel drive allows full rated lifting capacity at all positions of swing without outriggers. Automatic transmission and torque converter are standard on the ⅜-cu yd, 7-ton crane.

(29) CORE DRILL: The new model JS core drill by *Pennsylvania Drilling Co.* is designed with a low center of gravity and wide skids to provide stability in rough terrain. Power is supplied by a 30-hp gasoline motor with 6-v starter. Unit incorporates an integral 20-ft aluminum derrick and optional cathead. Drill is offered with either an AW or NW 24-in. feed hydraulic swivel head.

(30) NI-HARD CASTINGS: An illustrated list of some available grinding mill liner designs comprises one section of a new *Nordberg Mfg. Co.* bulletin detailing Ni-Hard castings. Bulletin 263 covers such applications of the nickel-chromium white cast iron as ore chute liners, dredge and shovel teeth, slurry pump parts. Included are charts covering abrasion resistance and hardness.

(31) SLURRY PUMP: *Krogh Pump & Eqpt. Co.* offers bulletin 601 which covers the newly developed model 600 sand and slurry pump. Unit is full lined with replaceable and interchangeable metal and rubber liners. A cross-section view shows construction details and parts list. Included is capacity chart which gives performance characteristics for an average sand slurry.

(32) FLEXIBLE SHAFTS: Four-page bulletin F-11 from *H. S. Watson Co.* supplies engineering information on flexible shafts.

(33) CAR RETARDERS: Bulletin 173 from *Union Switch & Signal*, div. of Westinghouse Air Brake Co., details Electro-Pneumatic car retarders for industrial applications. Such mechanized systems of controlling coal and ore railroad car movements can reduce operating costs and manpower needs and permit increased operating speed. Model 31 retarders consist of 6 ft 3 in.-long units with individual power cylinders. Unit construction permits installation on curved track when extra space is needed.

MAIL THIS CARD

for more information on items described in Manufacturers News and for bulletins and catalogs listed in the Free Literature section.

3

Mining Engineering **29 West 39th St.** **New York 18, N. Y.**

Not good after June 15, 1958—if mailed in U. S. or Canada.

Please send { More Information ☐ / Price Data ☐ / Free Literature ☐ } on items circled.

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Company_____

Street_____

City and Zone_____ State_____

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
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41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	Students should write direct to manufacturer.					

(34) TITRATOR: Assay offices and laboratories may be interested in bulletin 355 from *Photovolt Corp.*, describing the Lumetron colorimetric titrator model 401-T. Photovolt believes it to be "the first commercially available equipment for rendering color and turbidity titrations independent of individual judgment and thus fully reproducible from one operator to another."

(35) PLASTIC-ZIPPERED FILTERS: Filtration Fabrics Div., *Filtration Engineers*, offers information on custom-tailored filter cloth bags with corrosion-resistant polyethylene zippers. The jam-proof zippers ride in smooth grooves with no teeth to snag or collect material and are available with either lip-type closure, which withstands 80-lb pull, or conventional slide fastener.

(36) COAL DRILLS: Two new hydraulic coal drills by the *Long Co.* combine light weight with high horsepower. Made of aluminum and designed to operate at 2000 psi, the new models 1-M-20 and 1-M-30 can be easily and quickly interchanged at the face. The 20-lb 1-M-20 is designed for powder hole drilling, and the 30-lb 1-M-30 is especially applicable for Airdox and Cardox holes. As each is designed, the electric motor operates and oil circulates only when the auger is rotating, and the independent hydraulic power unit prevents tampering with the relief settings.

(37) EXCAVATOR: A new 4-page brochure from *Koehring Co.* details the crawler-mounted 805 excavator. The 805 may be used as a 2-cu yd shovel, 2 to 3-cu yd dragline or clamshell, or 52-ton lift crane.

(38) ADJUSTABLE-SPEED DRIVE: *Louis Allis Co.* has 12-page bulletin 2000 describing the Select-A-Spede adjustable speed drive. Unit is a variable-voltage d-c drive which uses an a-c power source for driving conveyors and other machinery. Horsepowers range 5 to 200.

(39) POWER PANELBOARD: A new heavy-duty fusible power panelboard is the subject of a new 4-page bulletin from the Distribution Assemblies Dept., *General Electric Co.* New board, designated Type QMR, is designed for max 600-v a-c service. Bulletin lists features, application data, ratings, dimensions.

(40) EXTENSIBLE CONVEYOR: Catalog G-123 from *Goodman Mfg. Co.* details the Ropex Type 192 belt conveyor which links to any coal loader or continuous mining machine. The high capacity 36-in. conveyor increases or shortens its length, under its own power, while running coal. Used with shuttle cars, it can keep length of hauls from face equipment to conveyor at a minimum.

(41) AIR COMPRESSORS: New general bulletin SG-1 from *Le Roi Div.*, Westinghouse Air Brake Co., describes an entire line of unit and stationary air compressors. Included are photos and data on seven basic models ranging in size from ½ to 100 hp. Design, speeds, and methods of lubrication and cooling are explained. Working capacities are also given.

(42) DUMP TRAILERS: *Loadmaster Co.* trailers are designed to reduce empty weight for higher payloads. A new hydraulic cam action lift system permits extra-high dumping angles for handling sticky clays and other hard-to-dump materials. Dump angle is as high as 80° on some models and 60° on the longest dump beds. Production models are being offered in capacities from 10 to 30 cu yd, with beds from 16 to 28 ft long mounted on single and tandem axles.

(43) SUCTION EQUIPMENT: *W. R. Ames Co.* has a bulletin on ABC suction equipment which includes a new aluminum pipe line. Line includes suction gaskets at each coupling, permitting a large off-center movement without breaking the seal.

(44) DUST CONTROL: *Day Co.* describes industrial dust control utilizing the type RJ dust filter in 8-page bulletin G-579. Included are facts on new design, efficiency, and operation, as well as dimensions and specifications.

(45) HELIWELDING: A newly revised 24-page catalog is available on Heliwelding, *Air Reduction Co.'s* inert-gas-shielded tungsten arc welding process for rapid joining of most light-gage metals and alloys. Advantages of the method are detailed and descriptions are included of manual, semiautomatic, automatic, and accessory equipment.

(46) DUST COLLECTING: A new 6-page bulletin (A-9157) on dust collection equipment is now available from the *Ducon Co. Inc.* The brochure describes a line of wet and dry type dust collectors and auxiliary equipment including cyclones, centrifugal and dynamic washers, dust and fiber filters, discharge gates, and trickle valves.

(47) PORTA-FEEDER: *Nolan Co.* is now marketing a hydraulic Porta-Feeder with several improvements over previous models. Unit, used in spotting cars for loading, is only 60 in. longer than the average mine car, has quick change dogs, removable wear slides, and pushbutton control from both sides of loading point.

(48) V-BELTS: A 16-page booklet entitled, "V-belts, the Testing, Inspection, and Control of their Quality," has been issued by the *Goodyear Tire & Rubber Co.* Fourth in a series, the new booklet describes testing of raw materials and finished belts. Quality control is explained in one section, another is concerned with experimental production.

(49) DIESEL ENGINES & FUELS: What diesel engine users should know and look for when selecting fuel is outlined in a 16-page booklet by *Detroit Diesel Engine Div.* of General Motors. Applicable to all makes which operate between 1200 and 3000 rpm, the booklet includes a fuel selection chart that points the way to best engine performance.

(50) MOTO-CRANE: An 8-page catalog by *Thew Shovel Co.* describes a new crane offering a full rated 35-ton lifting capacity on a narrow gage 108-in.-wide carrier. The model MC-530 includes such features as the Shear-Ball turntable mount and new square-tubular main chord boom design.

(51) WEATHER-PROTECTED MOTORS: Motors with enclosures built to NEMA Type II standards to meet all requirements of outdoor service are described in a new bulletin from *Allis-Chalmers Mfg. Co.* Brochure gives construction and mechanical features for horizontal and vertical motors of 250 hp and above.

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MINING ENGINEERING

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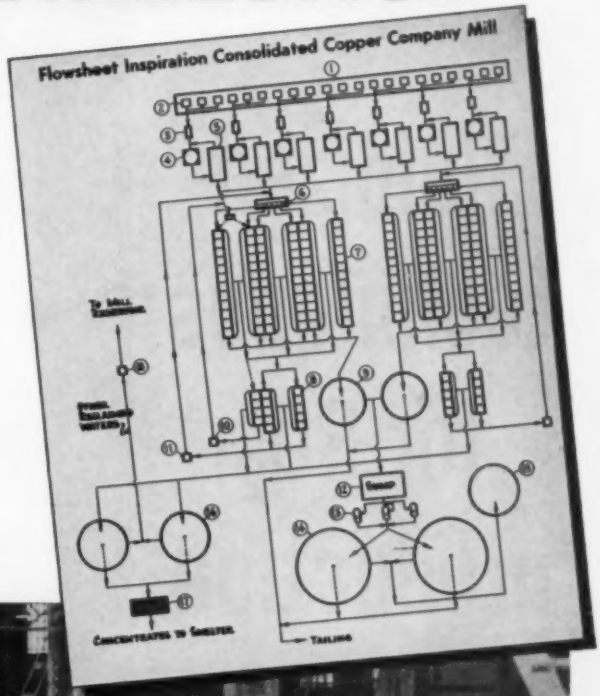
NEW YORK 18, N. Y.

INSPIRED METALLURGY*

extends INSPIRATION'S *reserves*

A new lease on life has been achieved by Inspiration Consolidated Copper Company, Inspiration, Arizona, through the complete rehabilitation of facilities idle for over a quarter of a century. Below are some of the highlights of the operation. For complete details, write for Wemco Bulletin F5-B30.

- **Dual Process, using acid leach for oxide fractions and flotation for sulphides.**
- **Increase in capacity, originally 10,000 tons, now 15,000 tons of ore per day.**
- **Simple flow sheet, with unique test circuit providing for a 2,500 t.p.d. pilot plant within the commercial circuit.**
- **Wemco-Fagergren flotation machines used throughout; 144 cells for roughing, 24 for cleaning.**



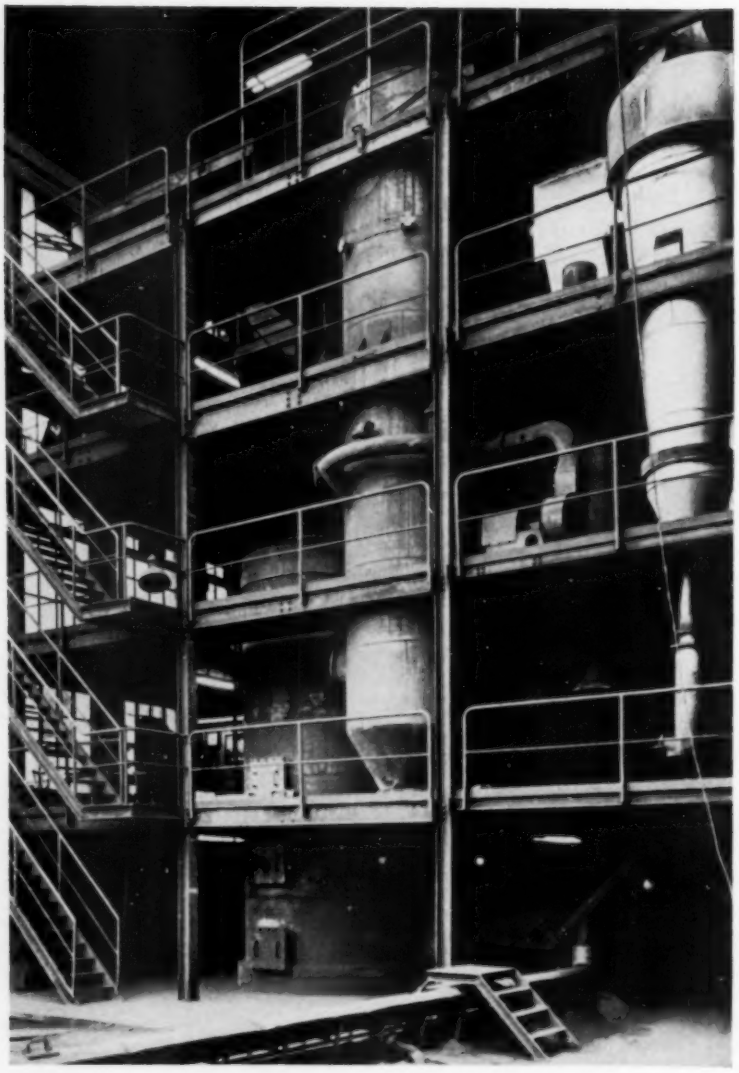
Wemco Fagergrens are controlled from a console, with a separate indicator for each unit.

WEMCO

WESTERN MACHINERY COMPANY
650 FIFTH STREET
SAN FRANCISCO 7, CALIFORNIA

Representatives in principal cities

fluidized techniques for SO_2 production in West Germany



The first installation in Germany of a Dorrco FluoSolids system for the production of SO_2 gas from pyrites recently went on stream in a large chemical plant. Main component of the system is the 7-foot diameter Dorrco FluoSolids Reactor in which 36 tons per day of pyrite containing 43% Sulfur is roasted at 900°C, delivering 10,000 CFM of SO_2 gas for the manufacture of 50 tons per day of 98% H_2SO_4.

Today, commercial applications of the Dorrco FluoSolids system for pyrite and pyrrhotites roasting total 52 reactors in 33 installations located in 12 countries. These units cumulatively produce the SO_2 gas necessary for the manufacture of over 5,000 tons per day of sulfuric acid . . . dramatic evidence of the world-wide acceptance of this most significant advance in roasting techniques in the last 35 years.

If there is a step in your flowsheet where intimate contact between solids and gases is essential, fluidization should be investigated. Dorr-Oliver research, design and engineering staffs in collaboration with our associated companies and representatives throughout the world can work to your advantage.

For complete information write Dorr-Oliver Incorporated, Stamford, Connecticut.

Dorrco and FluoSolids are Trademarks of Dorr-Oliver Inc., Reg. U. S. Pat. Off.

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INCORPORATED
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Kennecott Buys Consolidated Coppermines Property

White Pine County (Nevada) mining properties of Consolidated Coppermines Corp. have been sold to Kennecott Copper Corp. for $8.4 million. Included are: the Tripp pit, its contiguous holdings in Kennecott's adjacent Liberty and Veteran pits, numerous mining claims, water rights, surface buildings, equipment, the company-owned community of Kimberly, and other real estate. A Kennecott spokesman noted that "In recent years, necessary mining procedures have overlapped perimeters of two of the pits, creating conflicting interest and preventing badly needed economies necessary to be competitive in the world copper market."

Further Copper Cutbacks, Price Drop

January 10—Chile recommended 10 pct production cut affecting Kennecott and Anaconda subsidiaries in that country.
January 13—Kennecott Sales Corp. announced 2¢ reduction of refined metal to 25¢ U. S. delivered. Phelps Dodge followed with same cut.
January 14—Anaconda Sales Co. also announced 2¢ price reduction.
January 15—Union Miniere du Haut Katanga said it would cut output to 90 pct of 1956 total.
January 20—Phelps Dodge stated its output would be cut by 9 pct more (cumulative cutbacks since October 1956 total some 22 pct).
January 28—Kennecott and Chilean Government agreed to abolish 10-pct slash previously planned. Kennecott instead will reduce 1958 shipments of Chilean copper to Europe . . . . Anglo-American Mining Group announced 1-yr shutdown for its Bancroft mine (Northern Rhodesia). Move will effect 10 pct cut in total company output.

Zinc—All-Out Research, More Cuts

Zinc consumption was down 7 pct from 1956 last year and producers are looking to research to expand markets. Research-development projects are to be broadly placed in schools and research centers, according to American Zinc Institute . . . . Blackwell Zinc Co., American Metal Climax's Oklahoma subsidiary, has curtailed its smelter output by 2000 tons per month . . . . In the Coeur d'Alene district, Bunker Hill Co. announced a 4-day work week for its Bunker Hill, Crescent, and Star mines noting "the continuing weak condition of the lead-zinc market, reduced sales, and growing metal stocks."

Gold Clippings

Western Deep Levels, after 15 years planning will go 2½ miles down to open South Africa's biggest, deepest gold mine. Production is still about 6 years and £ 120 million away . . . . The Union produced record 16.5 million oz of gold during last fiscal year . . . . Gold remains Alaska's top commodity—production value jumped $1.5 million last year . . . . Canada reports placer activity in Quebec's Eastern Townships. Reason: early prospectors missed pre-glacial channels which can be traced with modern equipment . . . . Output of Canadian gold was up 2.2 pct over 1956 in first 11 months of 1957 . . . . Even though Hollinger Consolidated's gold mine is struggling in red ink, the company showed a profit rise in 1957. Saving factor: stepped up income from iron ore interests.

(Continued on following page)

Block Out Future Iron Ore Reserves

U. S. Steel's Canadian subsidiary Quebec Cartier Mining Co. has revealed, through application for a 200-mile private line rail charter, its study aimed at setting up an 8-million ton per year iron ore project in the Mt. Reed and Mt. Wright areas of Quebec. Official announcement has not been made . . . . Jones & Laughlin Steel has just leased a 5640-acre Mt. Wright property. J & L has also acquired 2020 acres in Wisconsin for taconite reserves through purchase and lease . . . . Bethlehem Steel is reportedly major backer of plans to mine rich iron ores at Mekambo in the Gabon, French Equatorial Africa. Big obstacle: need costly rail line to the coast.

Iron & Steel Production

AISI index of U. S. steel production fell to 134.6 in 1957, from 137.2 in 1956 . . . . Europe's Coal & Steel Community increased steel production by 5 pct last year over 1956. Community iron ore mine investments reached an estimated $65 million in 1957—still not enough to fill needs. . . . Pig iron output in the USSR has been getting less than full-faced Kremlin smiles. Last year's 4 pct increase was below most recent years and expansions are being pressed. Upstep, if successful, will see completion of 14 huge new blast furnaces in 1959.

Coal Developments

Britain's open pit coal output was 13.6 million tons last year—highest since method was first used in 1942. Total production was more than 223.6 million tons . . . . Philadelphia & Reading Corp. shuts down its inefficient mines, chops inventories, produces only what it can sell—proves efficiency pays by making money on anthracite! . . . Island Creek Coal Co. reported a gain of 5 pct in 1957 earnings, expects first quarter of this year to reflect "decline of general industry and of steel production."

Nickel Reports

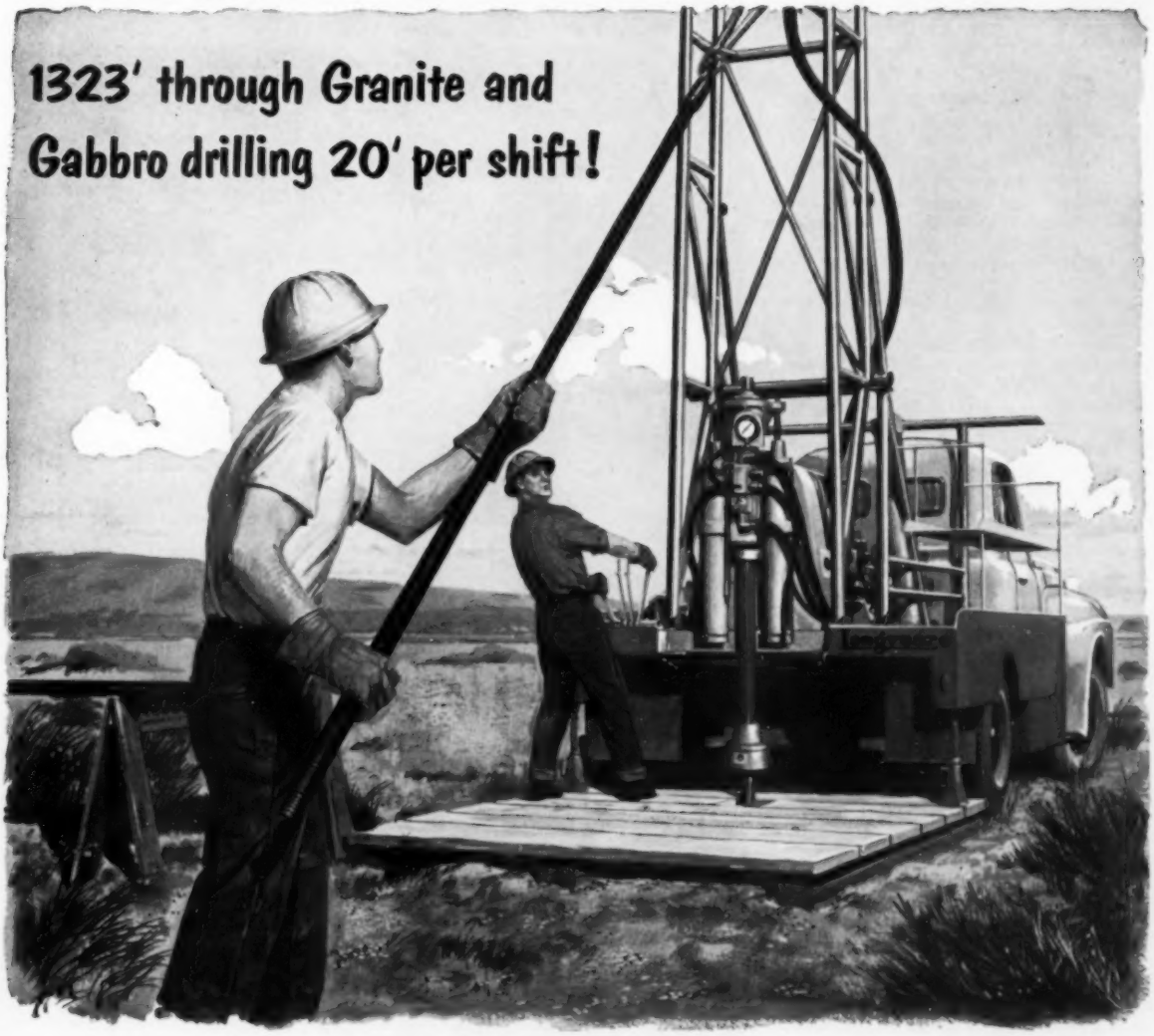
Two U. S. companies are scouting a potential nickel area in the northwest corner of California, near the Oregon line. New Delhi Mines Ltd. has already mapped out a lateritic deposit close by in Josephine County, Ore. This, in turn, is not far from the Hanna Nickel smelting operation . . . . Potential buyers of the government's Nicaro nickel plant in Cuba seem to be shying away for two major reasons: lack of guaranteed ore supply and an undefined tax. Government may solve this by offering lease with option to buy.

News of Nonmetallics

Ten 3500-ft test wells near Moab, Utah, have reportedly proven a large potash deposit for Delhi-Taylor Oil Corp. A $25-million mill is projected pending results of a market survey . . . . Perlite industry kept up sales level in 1957 in spite of a decline in the building materials industry. Output also held level—260,000 tons . . . . Calaveras Cement Co. is buying 550 acres of limestone properties near Redding, Calif. . . . . Texas Gulf Sulphur's mine near Houston has produced its 50-millionth ton of sulfur.

Report from the field . . .

1323' through Granite and Gabbro drilling 20' per shift!



Typical of Good Results With Longyear "W" Series Rods

Longyear "W" Series Rods head off trouble drillers encounter using ordinary rods. Here are four reasons why drilling costs are lower with "W" Series Rods.

1 Drill cuttings are discharged at the surface faster because the smaller space between the rod and the hole wall increases the velocity of the discharge water.

2 "W" Rods are stiffer. Increased diameter makes the drill string less flexible, more stable. Closer fit in the hole minimizes vibration, reducing gear and bearing wear in the drill.

3 Coupling openings are 22% to 88% larger than in E, A, B, and N couplings. Thus, with proper pumping facilities, an adequate water supply is more easily pumped across the face of the bit, minimizing the chances of burning due to lack of water.

4 Improved thread design makes coupling and uncoupling easier and faster.

Longyear "W" series rods are matched in advantages and performance by other components of Longyear *Coordinated Systems* for diamond drilling, including the finest drills, pumping units, diamond bits, and core barrels.

For complete information on Longyear "W" Series Rods, write for Longyear World No. 3, E. J. Longyear Company, Minneapolis 2, Minnesota

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THE WORLD IS OUR WORKSHOP

MINING engineering NEWS

Largest Copper Melting Arc Furnace Goes On Stream

Eighteen ft in diameter and with a bath capacity of 90 tons of molten metal, Asarco's new furnace can continuously produce 30 tons of tough pitch copper per hr.

A ton of pitch copper every two minutes!

This massive capacity enables American Smelting & Refining Co.'s newly installed electric arc furnace to handle the entire output of its large Perth Amboy, N. J., refinery.

Melting in electric arc furnaces, a common practice in steel making, appears to be a developing trend in the copper industry. Perth Amboy is the seventh copper refinery to adopt the method—and the biggest.

Unique features of the installation are its power/fuel ratio, its use of preheating and sulfur control, charging method, furnace size, and its highly responsive electrode control system.

Particularly significant, says Asarco, is the furnace's installation in an area of high power cost (about 1¢ per kwh) and reasonable fuel cost. This indicates that, even under unfavorable conditions, arc furnace installations can be competitive with the fuel oil-fired reverbatory furnaces conventionally used. For equal yearly production, capital cost of a large arc furnace and auxiliaries is less than that of multiple reverbatory installations and their auxiliaries. Moreover, the furnace turns out a smooth and continuous flow of uniformly high-quality copper of low sulfur content which can be cast at convenient rates. By contrast, a large reverbatory furnace requires that 300 to 400 tons of copper be cast in no more than 5 hr.

At Perth Amboy, Asarco has combined an oil-fired pre-heating furnace with the arc furnace to use both heat sources at top efficiency. Cathode sheet copper is heated to 1500 to 1600°F in a rotary pre-heating furnace which allows use of inexpensive oil. The heated, low-sulfur cathodes are then transferred to the arc furnace where the copper is melted and heated to 2100 to 2150°F. The molten metal is cast at 2030°F, flowing continuously by displacement and furnace tilt. From the furnace, the copper flows down a launder to a 10-ton electric holding furnace where its temperature and oxygen content are precisely regulated prior to casting.

Electric Arc vs Reverbatory

As furnaces go, Asarco points out, reverbatories are very inflexible affairs. They operate only on the batch principle in the copper industry, and deliver huge quantities of molten metal that must be cast rapidly into the many small shapes demanded by fabricators. In addition, they make slags that must be retreated, and use considerable quantities of expensive iron blow pipes, refractories, and poles. They have always demanded a large investment in waste heat boilers to make them thermally efficient, and in turn, this has required a use for the steam. The urge to replace them at Perth Amboy was not primarily due to lack of efficiency, however; it was more a matter of obtaining a continuous stream of molten metal which can be handled with maximum flexibility and control.

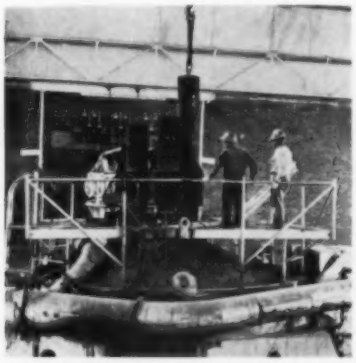
Copper Melt Problems

Operation of an arc furnace to melt copper poses special problems to furnace designers and operators. The arc discharges from the bottom of the electrodes to the molten bath, and requires accurate maintenance of an air gap of ½ to 1 in. Ripples due to charging or surges in the bath require an extremely sensitive control system to permit the electrodes to adjust automatically to the constantly changing conditions at the metal surface. If the electrodes are lowered too far, a short circuit results; if withdrawn excessively, the arc is snuffed. Obtaining necessary sensitivity of control in combination with rapid motion of the massive electrodes and their holders was a formidable requirement. Solution: use of a rotary regulator and controls actuating a hydraulic servo system.

Tests on the operating furnace show that electrode motion starts within 1/12 sec after receipt of the control signal. Despite the need to handle 10 tons of electrodes and holders, full reversal of the electrodes can be accomplished in 1/3 sec when the electrodes are traveling at a rate of 10 fpm.

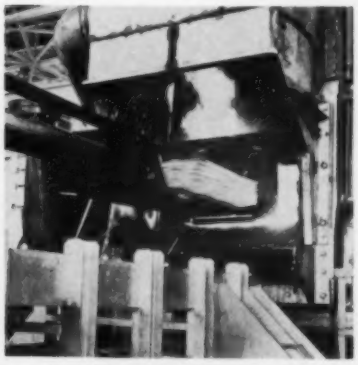
The electrodes are, of course, consumed continuously, and at periodic intervals the power is shut off for electrode addition. A new section of electrode is screwed onto the top of the existing section. Except for these additions, and infrequent periods for slagging, door cleaning, or adjustment, the furnace can be operated continuously.

1 Power switch-on brings in current rated at max 30,400 amp.



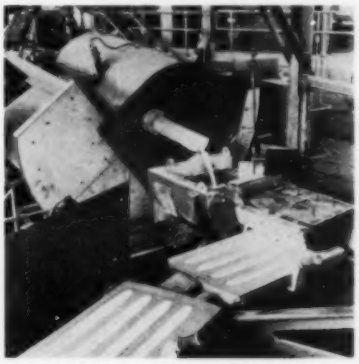
2 Asarco's furnace consumes one 18-in. diam, 2-ton electrode per shift.

3 Feed copper cathodes are divided into 1-ton piles and pre-heated.



4 Preheated stacks are swung to furnace. Scale at left shows tilt.

5 At control desk, ladle metal heat and furnace tilt are closely noted.



6 Tapped molten metal is run to induction furnace, then to molds.

7 Rotating casting wheel molds are cooled, bars dumped into water.

8 Pneumatic chisels chip defects from wire bars on inspection conveyor.

Moa Bay to Have Largest Sulfide Plant

Plans for a key unit in the $119 million nickel-cobalt project being constructed in Cuba and in Louisiana by Cuban American Nickel Co., a subsidiary of Freeport Sulphur Co., have been announced.

Cuban American has authorized construction of an automatic plant to produce 60 tpd of liquid hydrogen sulfide for its ore-concentrating facilities at Moa Bay, Oriente, Cuba. Girdler Construction Div. of National Cylinder Gas Co. will engineer and equip the facility.

Girdler Construction is also engineering a plant to produce 1.5 million cu ft of hydrogen per day as raw material for the sulfide plant, and will provide storage facilities for hydrogen sulfide and for the liquid butane which will be raw material for a steam-hydrocarbon process hydrogen plant.

Cuban American's nickel refinery will be at Port Nickel, La., near New Orleans. Its capacity will be 50 million lb a year of nickel and 4.4 million lb a year of cobalt when production begins in mid-1959. Limonite ore averaging 1.35 pct nickel and 0.14 pct cobalt will be mined near the Cuban plant at Moa Bay, where the ore will be concentrated to produce a nickel-cobalt sulfide, to be shipped to the Port Nickel refinery.

An *ore tanker* will shuttle between the two sites, carrying sulfur and liquid butane to Cuba as raw material for the hydrogen and hydrogen sulfide plants, and returning to Louisiana with the nickel-cobalt concentrate.

AEC Announces U_3O_8 Receipts for 1957

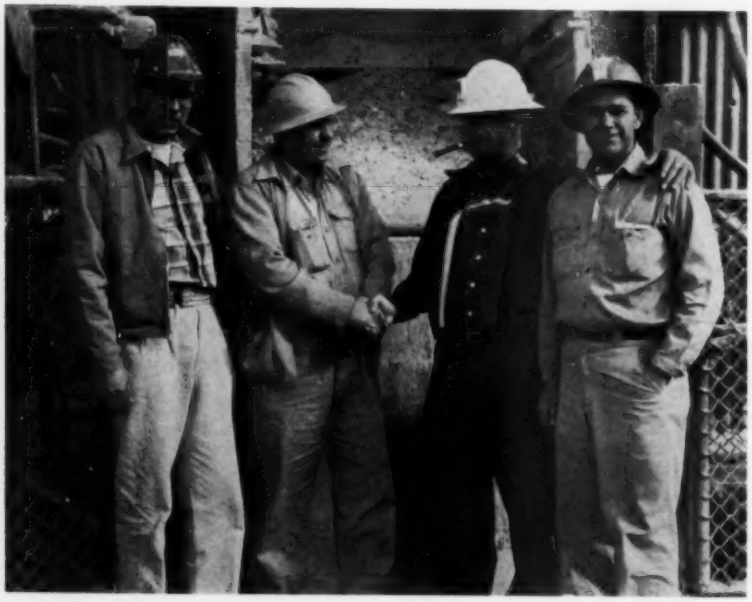
Uranium oxide concentrates produced in the U. S. and received by the Atomic Energy Commission during calendar year 1957 totaled 8640 tons. At year end, domestic concentrate production had reached an annual rate of 10,000 tons.

Included in this total are 146 tons which were produced as a byproduct in the chemical processing of phosphate rock in Florida and Illinois, from the treatment of Idaho euxenite at the St. Louis plant of Mallinckrodt Chemical Co., and from reprocessing of refinery residues at Vitro Corp.'s Canonsburg, Pa., plant.

Supplies from foreign sources amounted to 11,826 tons of U_3O_8 (December estimated), making a grand total of 20,466 tons.

At the beginning of 1957, there were 12 operating mills in the western U. S. Four more came into production during the year.

Potash Mine Hoists 30-Millionth Ton Of Sylvite



HANDSHAKES are in order and mine superintendent M. W. Kartchner, right center, congratulates mine foreman W. F. Eckland as the 30-millionth ton of ore is hoisted from IMCC's mine at Carlsbad, N. M. Flanking them are mine engineer A. V. Mitterer, left, and mine foreman G. E. Wiley.

Ore hoisting operations at the potash mine of International Minerals & Chemical Corp. near Carlsbad, N. M., came to a momentary halt on January 17, while company officials inspected a skip carrying the mine's 30-millionth ton of sylvite ore.

The 30 million tons brought to surface so far would bury every inch of the 107 miles of streets in Carlsbad under a pile of ore 33 ft high. Late in February, combined production from all levels is expected to reach the 40-million ton mark.

First ore from the sylvite level of the mine was hoisted for processing in October, 1940. The sylvite ore bed is one common to all potash mines in the Carlsbad area and at IMCC's property it occurs about 900 ft below the surface.

Langbeinite is also mined from deposits at the 800 and 850 levels. While sylvite contains potassium chloride, langbeinite is a double sulfate of potash and magnesium and in the U. S. is mined solely at the International property.

All ore from all levels of the mine is hoisted through the company's No. 1 shaft. Used only for ore haulage, it is equipped with 13-ton skips and an automatically controlled hoist which has brought to the surface as much as 14,464 tons in one 24-hr period. Estimated capacity when the mine was first put into production was just 1800 tpd.

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MINING engineering TRENDS

An Impressive Year's Survey

EACH year about this time the U.S. Bureau of Mines and the U.S. Geological Survey take a short breather and summarize their work of the year just past. The recap for 1957, while it shows no startling innovations, illustrates the steady research that brings continuing progress to every field. Both agencies deserve thanks for work that is often humdrum and frequently unsung.

In 1957 the USBM spanned broad areas with such projects as amassing complex data on domestic copper, lead, and zinc reserves, studying hydraulic anthracite mining, working up new mining methods for better recovery of limited high-grade U.S. bauxite, and producing and testing experimental quantities of high-grade boron metal.

Past labors showed their value also as a Bureau-developed top-fired scrap preheater was put to first use in cutting steelmaking costs, construction began on a huge new plant which will use a Bureau-perfected method for separating columbium from tantalum, and 100 new producing wells were drilled in a 34-year-old Arkansas oil field following the study of Bureau-published data.

Technologic and economic studies by the USBM pointed to increased security for the Nation, as well as decreasing industry's work burden. Besides studying world mineral and fuel production, requirements, and reserves, it acted as technical consultant to defense agencies with often complex problems.

In the metallurgical field, the USBM developed a method for producing super-high-purity titanium by electrorefining scrap and offgrade sponge and showed that difficult titanium shapes can be made by casting.

Accident-prevention courses were heavily programmed. Some 17,000 men were given the 20-hr course of instruction in coal mine safety, bringing the total since 1947 to about 195,000.

The U.S. Geological Survey was especially active in its publication of maps. During fiscal 1957, 1458 new quadrangle maps were published and 376 others were reprinted. In all more than 7 million copies were reproduced. Photogrammetric techniques are being used with great effectiveness in obtaining geologic data and the USGS's pioneer work in the physical sciences applied to prospecting is showing its worth in the present use of geophysical, geochemical, and geobotanical methods.

Last year, the agency also made studies of mining areas to apply the principles of ground-water hydrology to the dewatering of mines. And the Survey makes results of its work known. More than 3500 maps and reports were made available in 1957.

Chromium-Armored Molybdenum

A happy marriage with chromium allows molybdenum to withstand working temperatures higher than 2000°F thanks to a new surface-alloying technique.

The development, announced by Chromalloy Corp., holds down molybdenum's affinity for oxygen at great heat—which usually causes fast erosion and eventual deterioration—and allows the metal to retain its natural great strength at high temperatures.

By the new process chromium is diffused into the surface of the treated molybdenum, giving it high resistance to oxidation and making it useful for such applications as gas turbine blades, ram jet flame holders, turbine wheels, gas generator assemblies, thermocouple protection tubes, nuclear reactor rods, heat exchanger tubes, and missile combustion chambers.

Fuels and Lithium

LITHIUM facts and figures, from the metal's discovery in 1807 to its use in high energy fuels and atomic fusion, have been interestingly assembled in a cost-free brochure from Montgary Explorations Ltd., Toronto.

The 24-page booklet with six charts and 14 illustrations points to the world's principal present and potential sources of lithium and includes current prices, principal uses, and producers.

Aid for Boron

LARGEST producer of boron minerals, U. S. Borax & Chemical Corp., has asked for government aid in increasing the depletion allowance on borax from 15 pct to 23 pct. President H. M. Albright, making his request before the House Ways and Means Committee, pointed out that stepped up uses for boron in such applications as high energy fuels would result in hastened depletion of the known deposits of the California desert.

Mr. Albright claimed the increased allowance would be essential to new discovery and development and said the mineral's new uses qualify it as a strategic material, entitled to inclusion with other minerals receiving percentage depletions at the 23 pct rate.

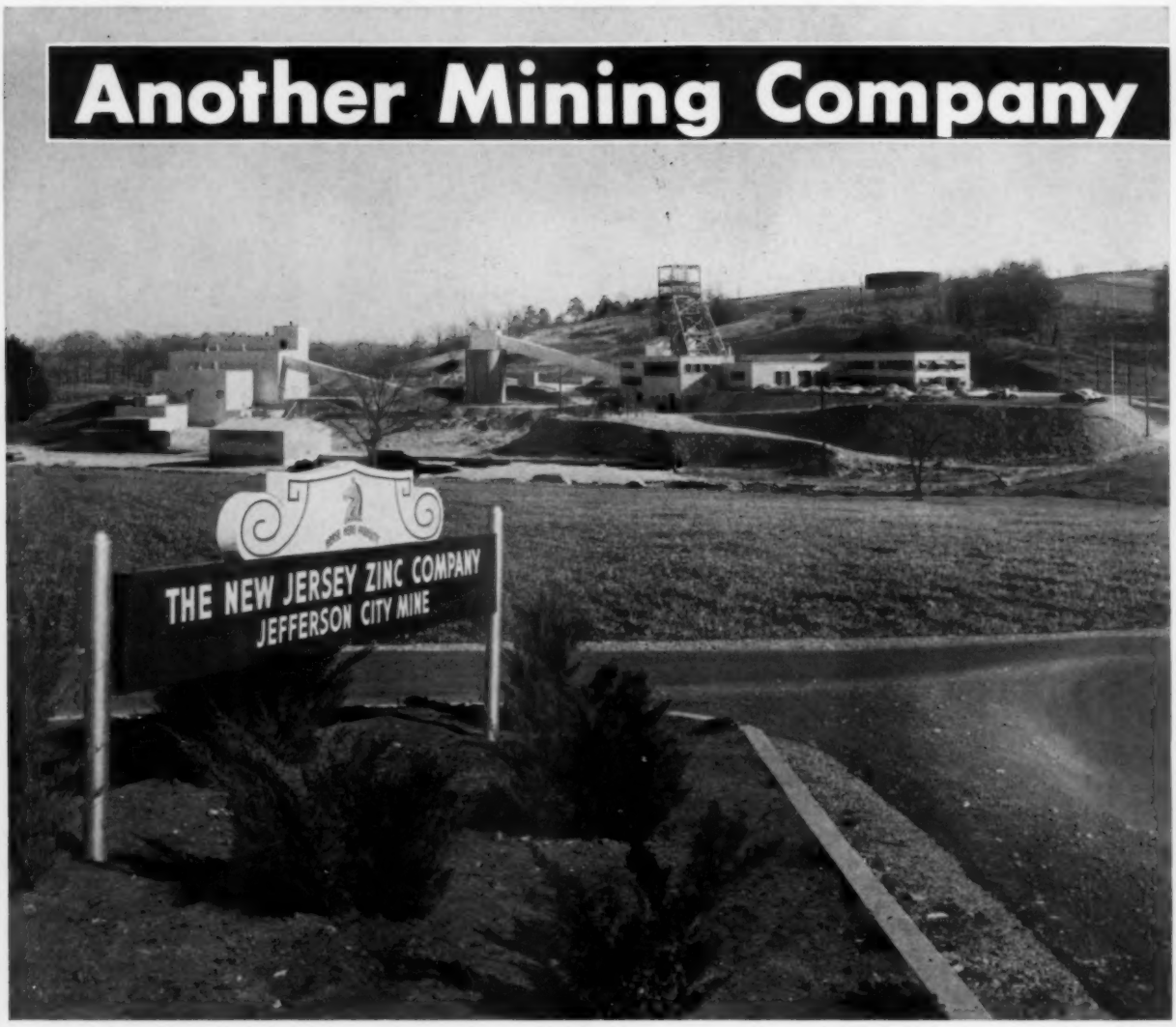
Borax output in the U.S. has been more than tripled in the past ten years, he said, and it is expected to at least double in the next ten. About 1 million tons are now produced yearly.

Mining and Metals Allure

MINING and metals industry securities appear to have taken tall ratings with the members of the National Assn. of Investment Companies in recent years. The 167 members, most of which are mutual funds companies, last year diversified their investments among 127 mining and metals stockholdings in the industry amounting to a value of more than $476 million.

A little more than a year previous, member holdings in the field were in 111 corporations and valued at about $400 million. Two years ago, the association reports, member companies' holding of common stocks in the mining and metals industry were in 139 corporations and valued at $308 million.

Another Mining Company



This is a new important mining operation that is taking advantage of the cost saving benefits made possible by the Gismo Self-Loading Transport. The Jefferson City Mine of The New Jersey Zinc Company is an example of the result that can be obtained by careful planning, design and selection of equipment.

This Gismo machine makes it possible for you to devise and organize a simple mining method. We believe the lowest cost possible is obtained when your plan provides for the fewest pieces of equipment, supplies and men. The Gismo is simple, versatile — mucks in development or production, can drill as a jumbo, make its own roadways, etc. It can transfer its load direct to cars by means of ramp cars . . . or direct to cars or trucks by means of ramping-over (see circled photo at right) . . . or direct to surge pocket for transfer to a common haulage system or method.

Investigate the extraordinary economies that have been obtained with the use of this remarkable machine. Its principle provides you with a new fundamental opportunity to devise ways and means of cutting costs that you have not had for many years. Write us today. Sanford-Day Iron Works, Inc., Knoxville, Tenn.

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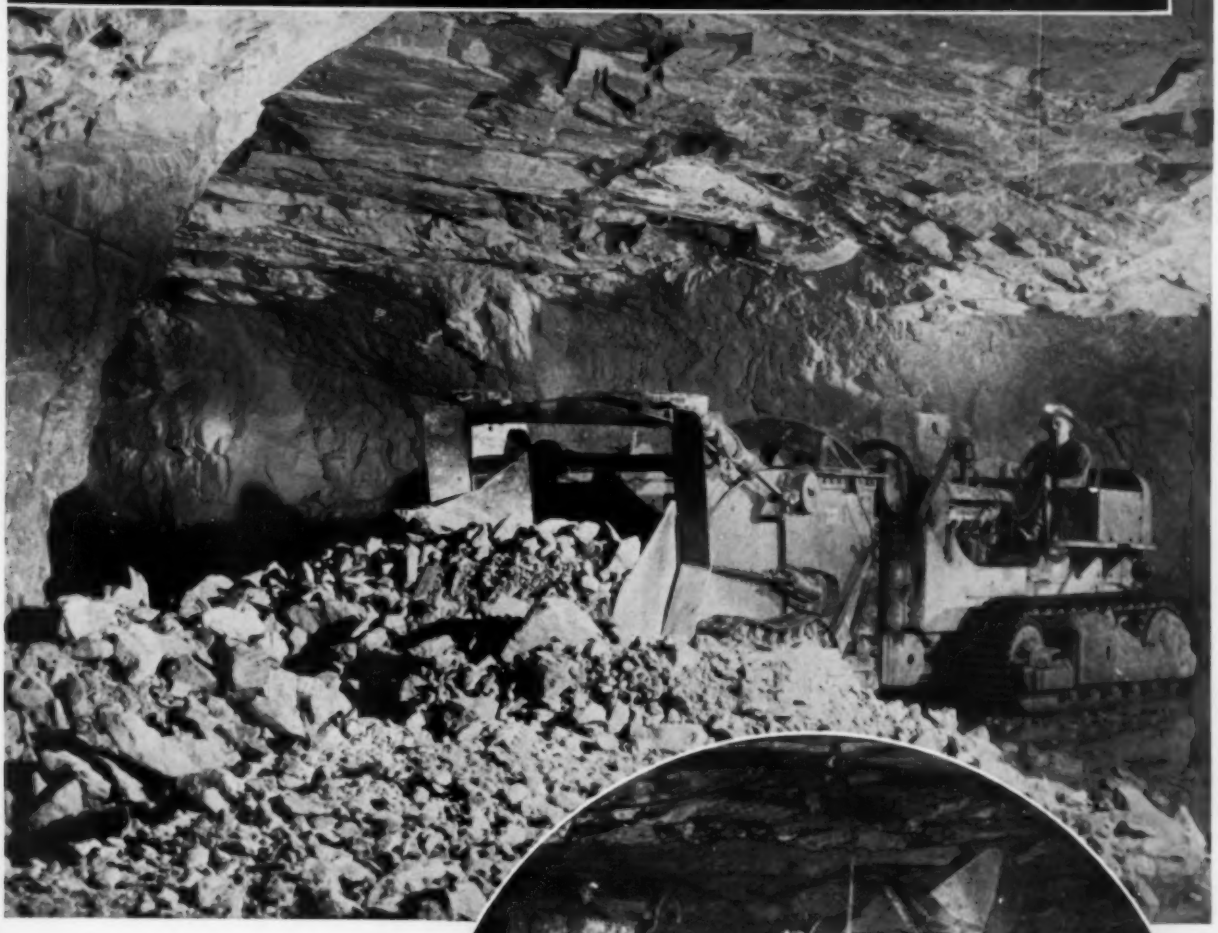

THE NEW JERSEY ZINC COMPANY'S Jefferson City Mine incorporates the latest and most modern equipment, including the Gismo, S-D Ore Cars and S-D "Brownie" Hoist. Above you see the Gismo mucking out a load. Circled photo at right shows the ramp-over-cars' transfer point. One man, the Gismo operator, handles the entire operation by means of push-button control of the S-D "Brownie" Hoist. Operator's control lever is located just below roof above the ramp. The S-D "Brownie" Hoist automatically moves trip when another empty car is positioned under ramp. Operating arm located beside cars "tells" hoist when to stop the trip. The S-D Ore Cars haul production to ore pass.

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By A. B. Parsons, formerly Secretary, AIME

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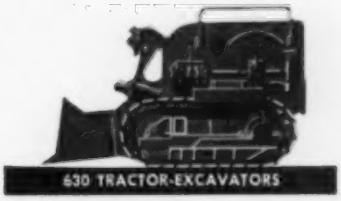

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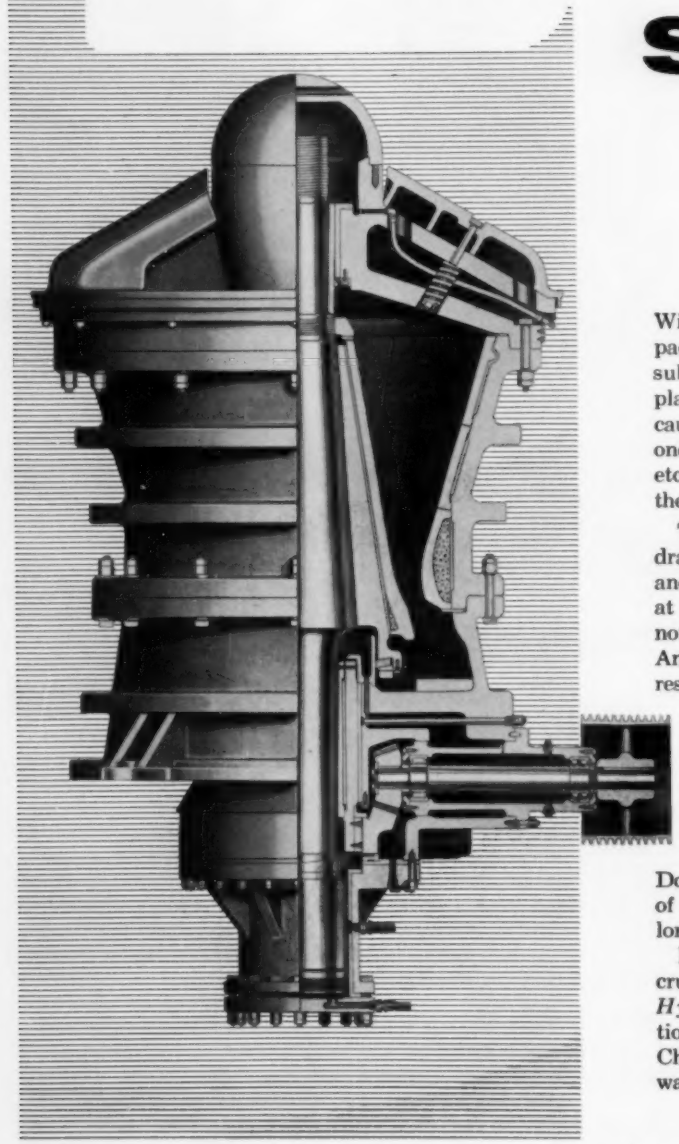

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With a *Superior* primary crusher setting the pace — *a fast pace* — you get the most out of subsequent equipment in your flow. Over-all plant operating costs are kept at a minimum because the entire circuit remains in balance. Secondary and tertiary crushers, vibrating screens, etc., may be utilized in sizes and types to meet the requirements of a constant tonnage.

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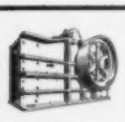
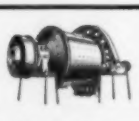

Jaw Crushers

Gyratory Crushers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The Porphyry Coppers—A Milestone

AIME brings up-to-date in *The Porphyry Coppers in 1956* the greatest saga of the mining industry. This new volume takes the story from the early 1930's to date, takes a roll call of the great low-grade copper mines—original porphyry coppers—and adds stories of the newer mines, the Bagdads and the San Manuels.

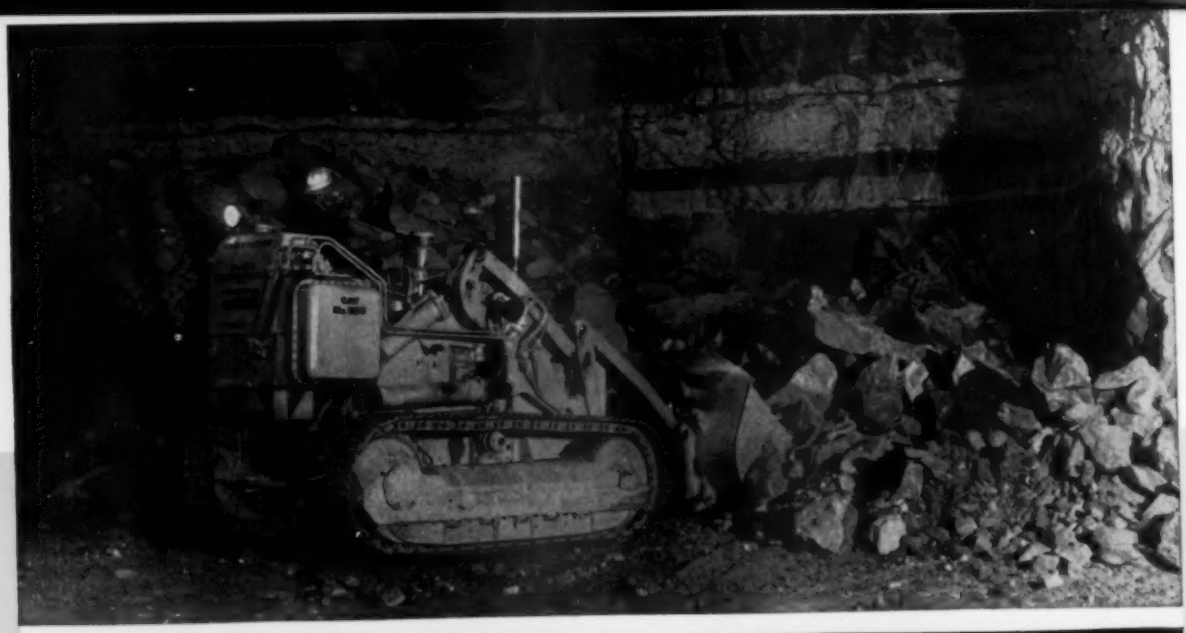
On the cover this month, MINING ENGINEERING salutes the new President of the Society of Mining Engineers of AIME, Stan Michaelson. Chief engineer of Kennecott's Western Divs., he symbolizes the second era of the porphyry coppers wherein the battle has been technological—rising costs have been combated with better technology to enable the production of vital red metal from ever leaner ores through the application of constant improvement in mining and milling and smelting methods. It is just this technology which has enabled the survival, in fact the growth, of an amazing number of original porphyry operations. Their founders would not recognize them but they are still great mines because of the application of ingenuity, of courage, and of advancing technology.

In this second edition of the *Porphyry Coppers*, more than a little of this story is retold, as text, illustrations, tables, and diagrams report the conversion of great underground operations to open pit mining, of the conversion of open pit operations to underground as pit limits became excessive. They tell of the era when rail haulage began to be replaced by rubber-tired vehicles and the growth of these vehicles to tremendous sizes. For content detail, see page 324.

In the mills there have been fewer evolutions in technology but the mills themselves have been constantly refined for ever higher recoveries and ever greater efficiencies. Pieces of equipment have grown not only larger but more efficient and studies ranging from refinement of reagent application and flotation to reduced energy input with greater grinding mill output have provided another part of the battle with rising costs and lower grade and deeper ores.

We call it a saga—and it is that, for the porphyry coppers have set the pace, provided the thinking, the stimulus for much of the rest of the mining industry. Today, the early era of the porphyry coppers is being repeated in the great taconite plants springing up not only in Minnesota but in New York and also ultimately in much of Canada. In the *Geology Annual Review* in February MINING ENGINEERING, Edward Wisser wrote, "The momentum of porphyry copper thinking . . ." in short, the term has gone beyond its original meaning as a labeling of a limited group of similar mining operations based on low-grade disseminated copper ores. The bold concept of efficient mass handling of large low-grade ore bodies has gone far beyond those first coppers. In fact, it is today the thinking of the mining industry.

—R. A. Beals



WHEN MINING OR QUARRYING CALL FOR FAST, CLOSE-QUARTER LOADING—

Operators such as Floyd Davis like the Cat No. 955 Traxcavator with Side Dump Bucket because they can see where they are casting, and operator movements are kept to a minimum.

perfect answer is a CAT-built Traxcavator with Side Dump Bucket

This No. 955 Traxcavator with the new Side Dump Bucket Attachment is loading limestone for the Southwest Lime Co. near Neosho, Mo. Because of its in-line loading capabilities—just power it forward and reverse, no turning—it is easily able to do the work of *two* other machines (HT4s). Working underground in quarry rooms where turn space is at a premium, this speedy Caterpillar unit dumps both forward and to the left.

The new Side Dump Bucket is available for the Cat No. 977, No. 955 and No. 933 Traxcavators, with bucket capacities of 2¼ cu. yd., 1⅝ cu. yd. and 1⅛ cu. yd. respectively. Where you need elbow room, particularly in underground work, these durable units can't be matched for low cost-per-cu.-yd. material handling. And the Side Dump Bucket is interchangeable with the standard bucket—same pins, bolts and nuts used for mounting both.

In the limestone mining job shown here, the faster cycle time of the Side Dump Bucket unit is important because trucks haul the stone 300 yd. to the crusher. A slow loading operation could slack off the whole job. In other operations, too, these agile units keep production high . . . backfilling trenches, loading asphalt or concrete, removing snow and ice, excavating loose material.

This quarry site of the Southwest Lime Co. is producing about 700 tons of limestone per day for shipment to Kansas City for steel production. The Cedarapids crusher breaks the rock down to 7-in. lumps or smaller, before it is burned and shipped.

Side Dump Bucket Gives You—

1. Less maneuvering. Just a simple forward-reverse movement
2. Good view of loading field so operator can cast accurately
3. No turning to load
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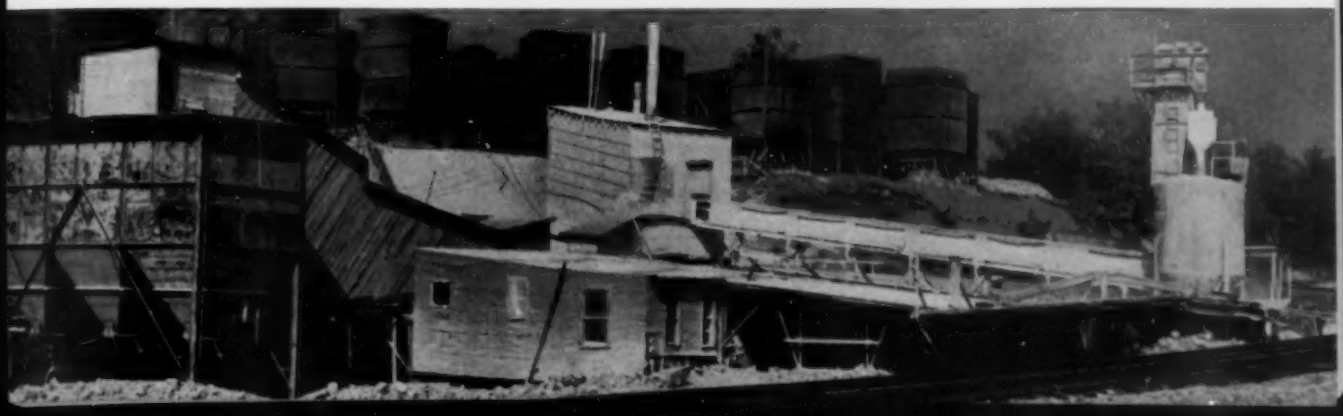

the profit you left behind

There it lays in the dirt. Your machines and equipment ground off in the grit, pounded off in the rock and ore. You can almost see the wear that shut down your machines too soon . . . idled your men too long . . . bled your profits too much.

Is there *one* material, *one* metal that can stop this excess wear waste?

One? It takes many alloys, engineered alloys (some you may never have heard of). It takes a list of Amsco® Alloys to span the entire range of wear applications.

Amsco Alloys that can work a full shift where severe abrasion knocked out toughest metals in three hours. Amsco Alloys that can belt rock and ore all day, and work tomorrow, too. Amsco Alloys that can work any abrasion-impact combinations you face and still resist the wear, stop the waste . . . save the profit!

When you need the *best* alloy for the job, you'll find it *first* among the Amsco Alloys . . . engineered by America's largest producer of cast manganese steel and specialists in wear-resistant metals.

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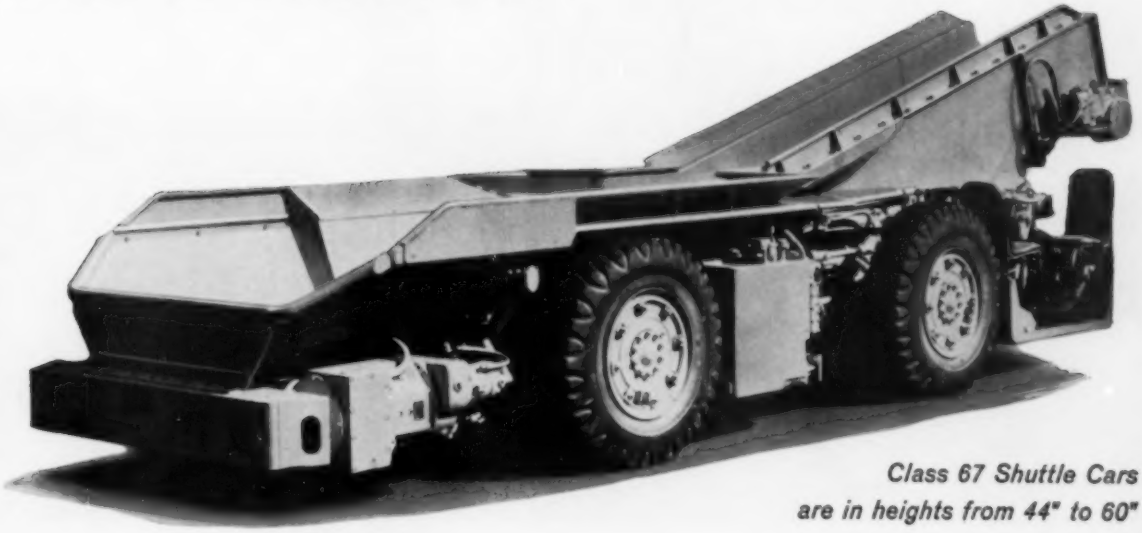

Class 67 Shuttle Cars are in heights from 44" to 60"

Jeffrey shuttle cars...

available in AC or DC power

67 MT Shuttle Cars work efficiently on grades 20 to 26%

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THE MACHINES THAT WORK FULL TIME

El Salvador Reports on Inca Adit Progress

El Salvador's 14x17-ft tunnel will pass through more than 3½ miles of faulted ground. Two-deck jumbo and Cuchafleta muck train speed advance.

by H. E. Robbins, T. H. Dudley, and E. A. Lucero

EL Salvador mine of Andes Copper Mining Co., subsidiary of Anaconda Co., is in northern Chile about 18 miles north of Potrerillos, 7825 ft above sea level. Initial production is planned for the first half of 1959. Plant capacity will be 30,000 tpd, and there are 308,835,000 tons of proven ore reserves, averaging 1.49 pct Cu. The Inca adit is being driven as part of the mine-to-mill haulageway.

Because of the overburden it is planned to mine the deposit by block caving. Ore will be dropped from upper gathering levels through ore passes to the Inca adit, through which it will be transported out of the mine to the primary crushing plant located a half mile from the portal.

The tunnel was portaled Aug. 1, 1956, and will be 3.64 miles long when completed. The section is a 14x17-ft horseshoe. The rock through which the tunnel has passed to date is an andesite agglomerate. The first 475 ft of the tunnel are in the oxidized zone, the remainder in fresh rock. Numerous fault structures ranging from weak to very strong have been cut. The largest have caused relatively little trouble because they are cut at nearly right angles to their strike, which is northwest. The other prominent set of structures, with an east-west to northeast strike, very nearly parallels the bearing of the tunnel and has caused some difficulty.

The tunnel is being driven, one face, with rail haulage—the only equipment not on track is a crawler-type overshot mucker. Two 10-ton and two 15-ton battery locomotives provide tractive power. Surface installations consist of a 2500-cfm compressor supplying air at 90 psi; a shop equipped for welding, blacksmith work, small lathe work, and general repair; a garage for truck maintenance and major overhauls on the mucking machines when they have to be removed from the tunnel; a pipe shop for fabrication of 38-in. ventilation line; electrical facilities, including lamp house, repair shop for the locomotives, and battery charging racks; and a dumping bridge and bins for disposing of muck.

H. E. ROBBINS is General Superintendent, T. H. DUDLEY Assistant Mine Superintendent, and E. A. LUCERO Tunnel Foreman at the El Salvador Mine of Andes Copper Mining Co., Chile.

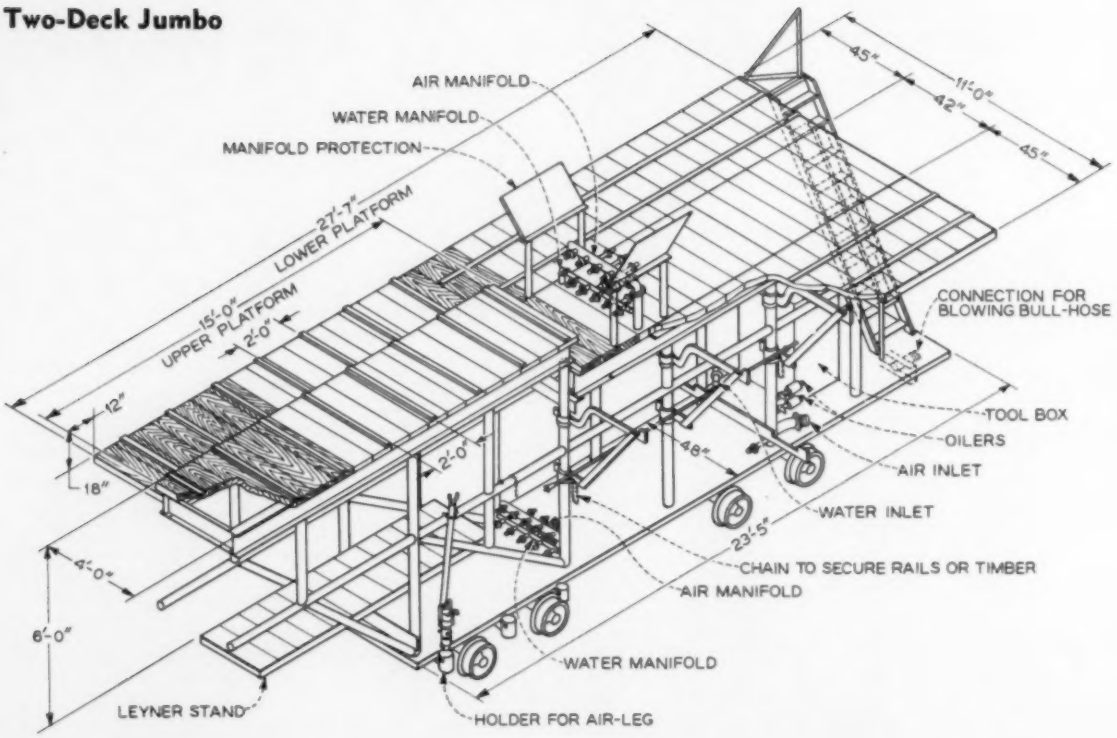
The present staff comprises a tunnel foreman, six shift bosses, a mechanic, and an electrician, who direct the 15 face bosses in charge of the crews. There are three heading crews, a track crew and timber crew on maintenance behind the face, mechanics and shop men, electricians, and surface crews to dispose of muck and handling material—234 men altogether. Heading crews are made up of 30 men in addition to the shifters and actually consist of two crews, one driving the heading and the other rock-bolting off the back end of the jumbo and putting in ventilation line. All work at the face is done by the heading crew. There are three shifts per day during the seven-day work week, the shifts changing at the face.

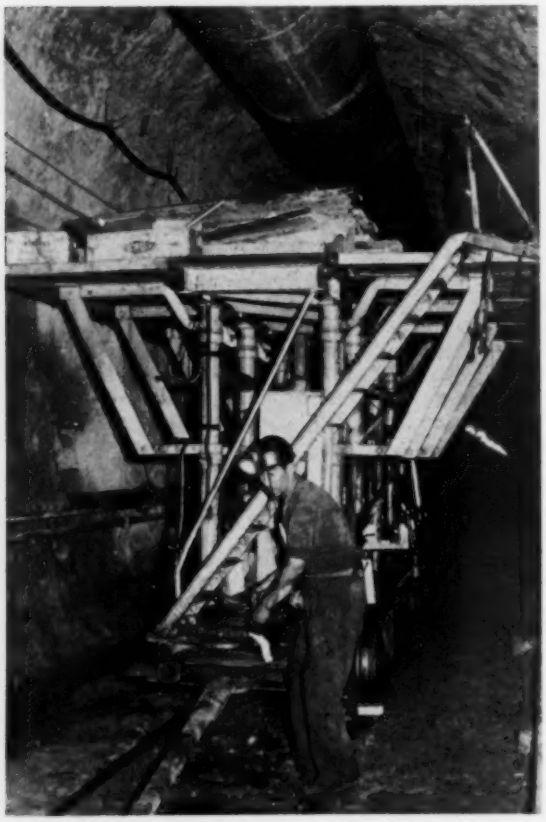
Drilling is done from a two-deck jumbo with 12 airleg drills on telescopic legs. An 8-ft hole is drilled with no steel change. At the start integral carbide steel with a chisel bit was used, but a four-point throw-away carbide bit is now being used on carburized steel drill rods, since it proved much easier to collar a hole with 8-ft steel using the four-point bit. Use of this bit also decreased chuck wear.

A 1⅜-in. hole is drilled, the holes per round varying from 59 to 94, depending on the ground. The type of round has been changed as conditions made this desirable, single and double pyramid cuts as well as a burn cut being used. The burn has been drilled only in the harder ground, and a drifter is mounted in the center of the jumbo to drill the burn. Holes in the burn are drilled 10 ft, the number of holes, usually seven, depending on drillout time for the rest of the round. At present a 76-hole round with a double pyramid cut is being drilled. Drillout time in October 1956 averaged 1.26 hr.

Blasting is electric, and standard delays are used except with the burn cut, which is loaded with milliseconds. Primers are made up in a primer house outside the tunnel and taken to the face in a special car. Holes are loaded with 1⅛ x 8-in., 45 pct ammonium gelatin in the primers, and 1⅛ x 16-in., 60 pct dynamite in the rest of the hole. This combination is used to get a 20 pct greater loading density at the hole bottoms. A standard electric blasting circuit is used with a shunt between the face and

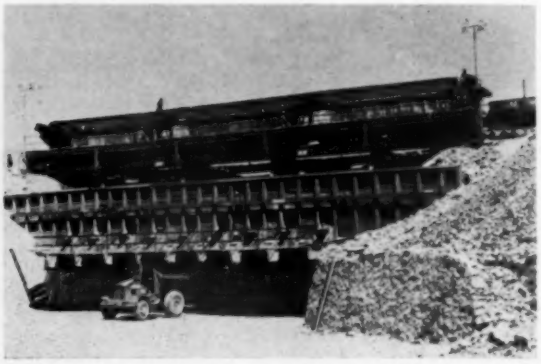
Two-Deck Jumbo



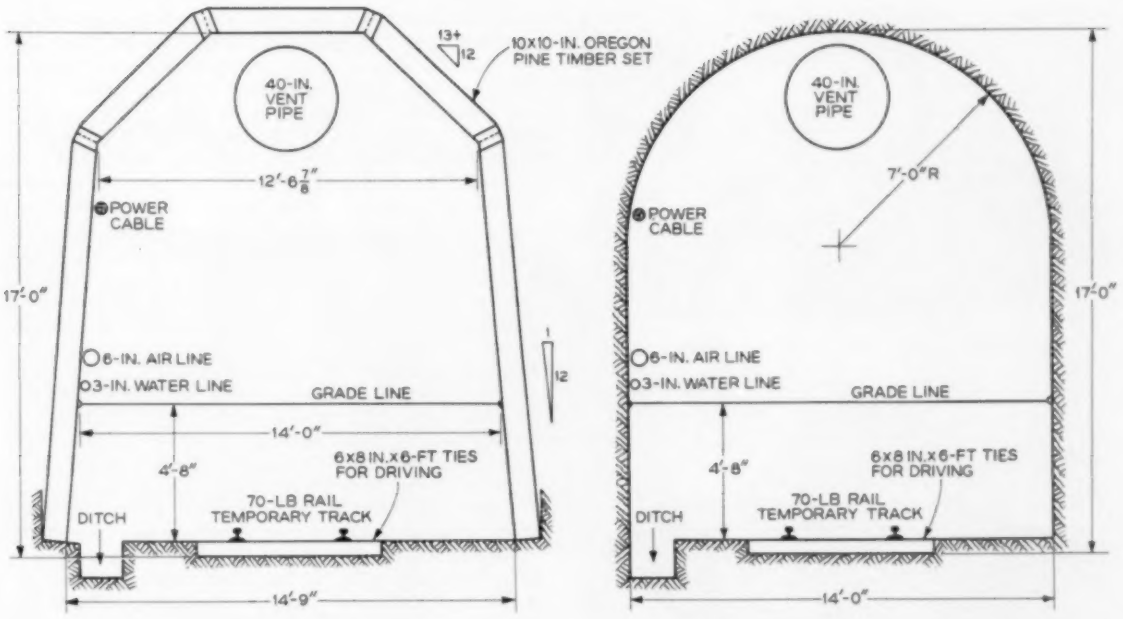


Note ladder in this rear view of two-deck jumbo. All equipment rides on rails except crawler-mounted overshot mucker.

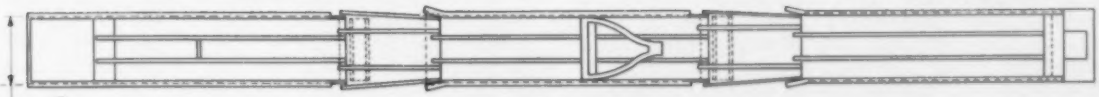
Powder car and jumbo are withdrawn by battery locomotive.



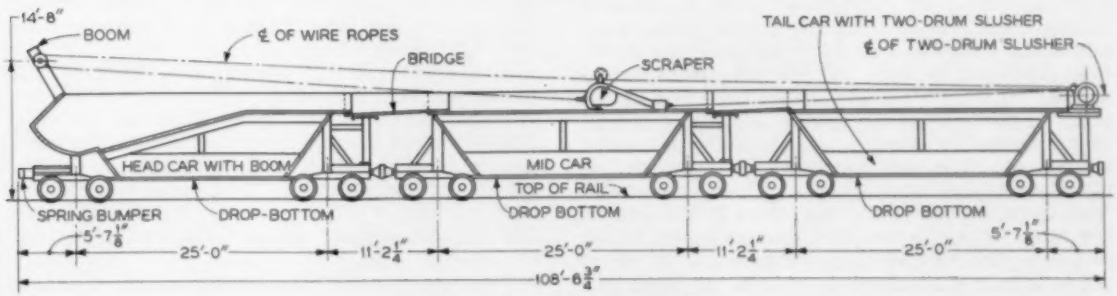
Cuchufleta, a train of gable-bottom muck cars dumps its full-round load, about 130 tons, outside the portal on a trestle. Bins empty into trucks for disposal. See diagram, more photos on right.



ABOVE: Cross sections of adit. LEFT: Interior view of *Cuchufleta*. Muck is dumped at far end shown and is scraper-drawn to fill cars. Note bridge spanning car coupling. RIGHT: In outdoor demonstration, 6-ft-wide scraper rides rails as it loads material. Muck is piled over rails for greatest capacity. BELOW: Diagram of *Cuchufleta*. Side boards were added to cars for bigger payload.



PLAN



CROSS-SECTIONAL ELEVATION

Overshot mucker demonstrates underground loading method.

Loader operates on kerosene, employs water scrubber.

the main blasting switch. The bus is connected in reverse parallel, and squibs are used to test the circuit for each blast. Blasting is done with 440 v.

Mucking is done with a crawler-type loader, loading into the *Cuchufleta*.* The shovel is operated on kerosene instead of diesel fuel for two reasons: 1) with the higher grade fuel there is better combustion and therefore less carbon monoxide in the tunnel, and 2) with standard diesel fuel and poorer combustion there was not enough ventilation at the face to keep the engine running at full power, and there was also considerable injector trouble. Kerosene gives the shovel full power, and injector life has almost tripled. The shovel is operated with a water scrubber to which limestone has been added.

* Freely translated, "a bag full of tricks."

The *Cuchufleta* is a modification of a mucking device previously used in smaller tunnels, revised by E. R. Borcherdt and R. M. Stewart of Anaconda's Butte research department. It is a train of these gable-bottom dump cars adapted to take a full round without changing cars. Side boards of 2½ ft have been added and bridges placed over the couplings at the level of the original top of each car, which previously held 40 metric tons. A 50-hp electric double-drum scraper hoist is mounted at the back end of the train and a hopper into which the shovel discharges is at the front end. The tail sheave for the scraper rope is on a boom at the front end of the train on the level of the original car top. A special 72-in. Amsco Whisler-type scraper rides out of the hopper onto these rails carrying back the muck that has been dumped into the hopper. The train is loaded from front to back by the scraper up to the level of the rails. When the complete train is loaded to the rail level, the scraper then stacks muck on top of the rails from the back of the train to the front. The scraper hoist is operated by remote control through solenoid-controlled air cylinders, which control the clutch bands. The operator works near the front end of the train where he can coordinate the movements of the scraper with the shovel. Varying according to the operator's proficiency, the best muckout time with this equipment is 40 min. Depth of round has been standardized at 8 ft, breaking about 130 tons of rock. The trainload of muck is emptied into a bin outside the portal, from which it is loaded into trucks for disposal on the dump.

About 70 pct of the tunnel driven to date has needed support of some kind. When a section needs support, bolts are put in first. Ordinarily a ring of five bolts is set from the back end of the jumbo every time a round is drilled. If more support is necessary, screen is installed in conjunction with bolts. Timber is only used where the ground cannot be held with one of the other two systems. The timber placed is a 10x10-in., five-piece set, usually on 6-ft centers. In only one section was it necessary to reduce this to 2-ft centers.

Two types of bolts are used—the expansion shell type when bolts and plates alone are put in and the split-end and wedge bolt with plates when screen is used. For screening, it has been found that a 2-in. mesh cyclone fence of No. 8 galvanized wire is the easiest to install and that using a wedge-type bolt insures a tight screening job.

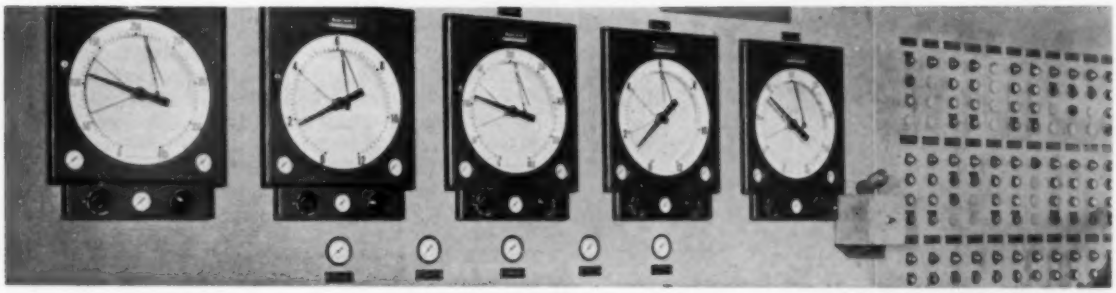
Two-stage, non-reversible axivane fans, set in 38-in. fan line, exhaust 20,000 cfm from the face. The first fan is set 1000 ft from discharge and succeeding fans are set every 3000 ft in the tunnel. The fans work at 6½-in. water gage. The fan line, fabricated in the pipe shop at the portal, is made in 20-ft lengths from No. 14 plate. Joints in the line are made with steel bands and sealed with felt stripping. The end of the fan line is kept within 75 ft of the face. A blower connected to an 18-in. flexible tube provides auxiliary ventilation. The flexible tube is carried directly to the face and pulled back for blasting. Sampling for carbon monoxide is carried out regularly with a colorimetric tester using yellow silica gel tubes. Carbon monoxide in the tunnel has been well below the allowable maximum at all times.

As a rule, the 15-ton locomotives are used only to move the *Cuchufleta*, and the 10-ton locomotives supply all the rest of the service. The 70-lb temporary track, on 3.281-ft gage, is for driving only and will be changed to 90-lb welded rail for the permanent haulage track. A turnout is put in every 2500 ft or so to allow passage of equipment, especially the jumbo and *Cuchufleta*, inside the tunnel. It has been found that if these turnouts get much farther behind the face, the time lost in substituting the *Cuchufleta* for the jumbo at the face increases rapidly and crews at the face lose too much working time. Small turnouts for storing the loader are kept as near the face as possible, usually not more than 350 ft back.

At the date of this writing, Oct. 25, 1957, the tunnel has been advanced to a total of 1.79 miles. From September 25 to October 24 it was advanced 1405.3 ft, or an average of 46.8 ft per day. The average cycle per round for 194 rounds completed during this period was as follows: drill out, 1.26 hr; load and blast, 0.46 hr; muck out, 1.39 hr; lay track, 0.17 hr; rock support 0.03 hr; and down time, 0.40 hr—total, 3.71 hr.

The best one-day advance during this time was eight complete rounds for a total of 62.67 ft.

Automation in the Mineral Industries



Coal preparation plant control panel.

by John McCaslin

ONE of the most common technical terms in the U. S. today is *automation*—a word not listed in the 1946 dictionary. The influence of automation on the national economy has been tremendous. It has even been the subject of congressional investigations.

Automation, writes Aronson, substitutes mechanical, hydraulic, pneumatic, electric, and electronic devices for human effort and decision.[1] Automatic devices and instruments are used extensively in some industries, but many others have yet to take full advantage of these great discoveries. The petroleum industry has been a leader in using automatic controls—some refineries are almost completely controlled by automatic devices. The field of geophysics is entirely dependent on instruments and has progressed at almost exactly the same rate as improvements in instrumentation. In metallurgy and mineral dressing use of instrumentation is increasing very rapidly. Mining engineers throughout the country are beginning to think in terms of instruments and controls.

Automation in the mining industry is generally thought of in connection with refining or beneficiation, and mineral engineers must learn the basic concepts of instrumentation to know where it can be used advantageously in their own operations. It is very doubtful that extracting ore or drilling for oil will ever become automatic processes. This does not mean, however, that instruments cannot be used to increase production and reduce costs.

What should the future engineer know about instrumentation and controls? Most of the measurements made in industry can be placed in the following categories:

Temperature
1) Mercury thermometers
2) Expansion thermometers
3) Thermocouples
4) Radiation-type thermometers
5) *Resistance bulbs*
6) *Thermistors*

Pressure
1) Manometers
2) Diaphram-type instruments
3) *Pressure transducers*

Strain
1) *Unbonded strain gages*
2) *Bonded strain gages*
3) Extensiometers

Flow
1) *Orifice meters*
2) *Venturi meters*
3) Pilot tubes
4) Rotometers
5) Magnetic flowmeters

Position
1) *Potentiometers*
2) Differential transformers
3) Servo-mechanisms

Vibration
1) Accelerometers
2) Velocity-type transducers
3) *Displacement-type transducers*

J. McCASLIN is Assistant Professor of Physics, Montana School of Mines, Butte.

This article is based on a talk given to the Montana Section of AIME March 20, 1957, at the Montana School of Mines.

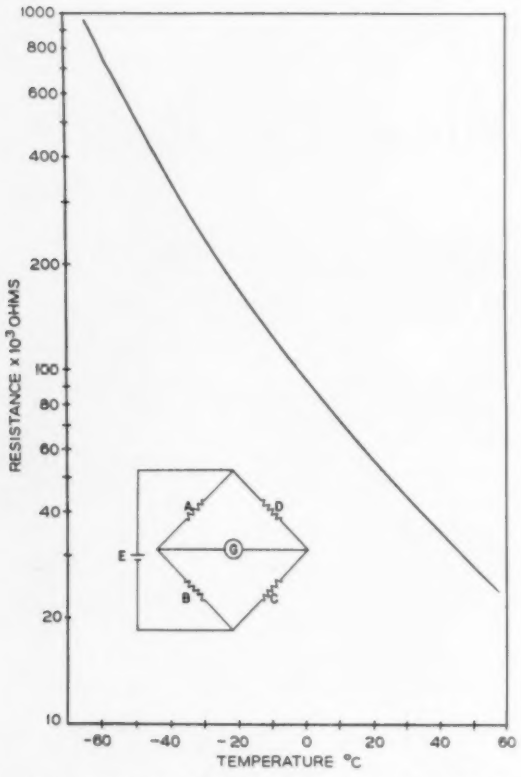


Fig. 1 (inset)—The Wheatstone bridge. Fig. 2—Output of the Wheatstone bridge with variation of resistance of leg C.

It will be noted that under each group at least one type of instrument is italicized. The reason is that in many cases these particular instruments are used in a Wheatstone Bridge circuit. In some instruments all four legs of the bridge are utilized, but in many cases only one leg is used as a variable with the other three legs held constant.

With reference to Fig. 1, using Kirchhoff's Law, the current through the galvanometer is found to be

$$I_g = \frac{E(BD-AC)}{R_g(A+B)(C+D)+AB(C+D)+CD(A+B)} \quad [1]$$

where R_g is the resistance of the galvanometer.

From Eq. 1 it is readily seen that the output from the bridge circuit is not linear. Fig. 2 shows the output of a bridge circuit when legs A, B, and D equal 1000 ohms, the resistance of the galvanometer is 100 ohms, and the voltage across the bridge is 1 v. The leg C is normally used as the variable leg of the bridge. Examination of the curve shows that the output is approximately linear in the region where the resistance of the variable leg is maintained at a lower value than the other three legs of the bridge.

To acquaint the reader with the various phases of instrumentation, each of the headings in the outline will be treated separately.

Temperature: Most engineers are familiar with the principles of mercury thermometers, expansion thermometers, thermocouples, and radiation-type elements. The use of resistance thermometers may not be so well known. The principle is simple, in that the change in resistance of a metal with temperature is measured. Resistance thermometers are usually constructed of wire wound on a form, if a high resistance element is desired, the wire must be of a small diameter and very long. Construction is somewhat difficult because the wire must be wound on the form in such a manner that it will not be placed in tension when the temperature changes. The chief objection to resistance-type elements is that the change in resistance with temperature is very small and the mass is, by necessity, quite large. This means that under changing temperature conditions the lag becomes a very important factor. The principal advantage of resistance elements is that temperature can be measured very accurately, especially under static conditions. Resistance thermometers made from platinum wire are usually used in the laboratory when extremely accurate temperature measurements are desired.

Normally the resistance winding itself cannot be used in any kind of a corrosive atmosphere, since corrosive action on the wire winding changes the resistance, causing an error in all measurements. For use in corrosive atmospheres the resistance element must be enclosed; this increases the total mass and causes an even greater lag under changing temperature conditions.

In the past few years many of the objections to resistance elements have been eliminated with the discovery of thermistors. Thermistors are semiconductors made from a mixture of oxides of manganese, nickel, cobalt, iron, zinc, titanium, or magnesium. They are constructed in the form of disks, rods, and beads as shown in the top part of Fig. 4. The bead shown is second from the left and is enclosed in the end of a piece of glass tubing. Some of the bead thermistors are less than ten-thousandths of an inch in diameter. These extremely small thermistors are very fragile, but the very small mass makes it possible to record almost instantaneous changes in temperature.

The chief advantage of thermistors is the great change in resistance with temperature. The approximate resistance of a thermistor can be found from

$$R_t = R_o e^{k\left(\frac{1}{T} - \frac{1}{T_o}\right)} \quad [2]$$

where R_t is the resistance at any Kelvin temperature T, R_o is the resistance at any reference temperature T_o, and k is approximately constant and depends upon the thermistor.

Examination of Fig. 3 reveals that the constant k in Eq. 2 is not an exact value. The curve in Fig. 3 is an actual calibration curve of an ML-419/AMT-4 thermistor, which is used to measure temperature from radiosonde balloons.

The element in the bottom part of Fig. 4 is a humidity transducer. The resistance of the element is determined by the water content of a lithium chloride mixture placed between two conductors.

Unbonded Strain Gages: Unbonded strain gages are constructed in different ways, but in each case the measurement is dependent upon the change in resistance with change in length of a wire. Fig. 5 shows the construction of one type of transducer, manufactured by Statham Instruments Inc. Four sets of wires are stretched between pins on the armature and the frame. Movement of the armature in either direction increases the length of two of the elements and decreases the length of the other

two. With a change in length of any of the elements there is a corresponding change in resistance. Thus if the outer elements are labled A and C and the two inner elements B and D and then connected as shown in Fig. 1, the output will increase. This can be shown by referring again to Fig. 5. If the armature is moved from left to right, the length of the elements A and C is increased, whereas the length of elements B and D is decreased. As a result the resistance of opposite legs of the bridge will change to increase the output of the bridge.

Unbonded strain gages are ordinarily constructed so that when no force is applied to the armature, the bridge is in balance. Armature travel is limited mechanically so that the elements cannot be overloaded. The force necessary to give a maximum displacement will depend upon the diameter of the wire and the number of windings placed on the element. The maximum displacement of the transducer shown in Fig. 5 is 0.0015 in. each side of the center point. The force necessary for maximum displacement can be varied from ± 1.5 oz. to ± 5 lb. The main disadvantage of the unbonded strain gage is that displacement must be measured from a reference point, i. e., either the armature or the frame must be at a fixed point.

Bonded Strain Gages: Bonded strain gages eliminate the chief disadvantage of unbonded strain gages, as measurement from a reference point is unnecessary. Fig. 6 shows gages manufactured by the Baldwin-Lima-Hamilton Corp. The gages shown are the larger types. Many of the gage elements are actually less than 0.25 in. long. The bonded strain gage is cemented in place so that it becomes an integral part of the member. The principle of operation is the same, since the change in resistance with length is measured.

Examination of Fig. 7a shows a bar or rod with strain gages A and B cemented to the upper and lower part of the member. If the bar is subjected to tension or compression, the strain—or change in length per unit length—is the same for the gage as for the rest of the member. Thus the change in resistance is proportional to the change in length of the member, since both gages are subjected to the same strain. Output is increased if the two gages are connected in opposite legs of a bridge.

If the bar is subjected to a bending moment as shown in Fig. 7b, gage A is placed in tension while gage B is in compression. Thus the resistance of gage A is increased while the resistance of gage B is decreased. If the two gages are connected as legs A and B in Fig. 1, output of the bridge becomes larger than it would be if only one gage were used.

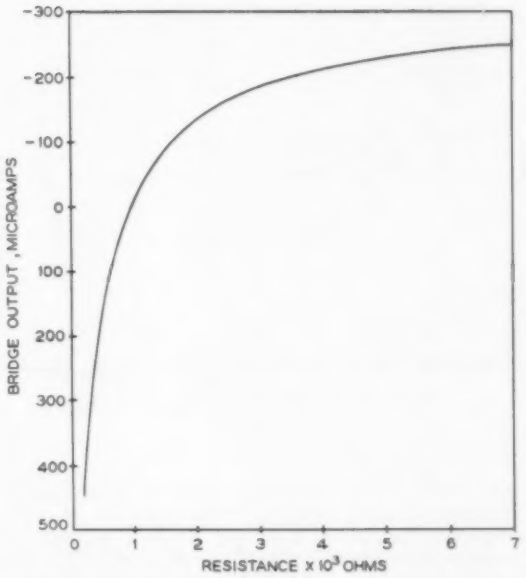
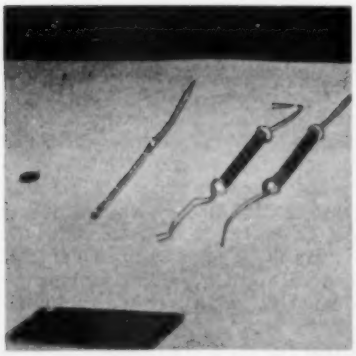


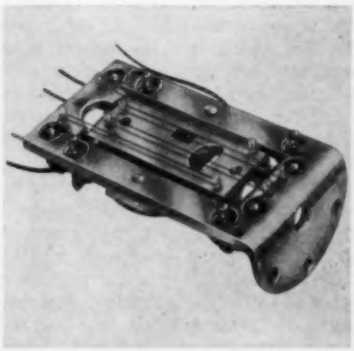
Fig. 3—Relationship between resistance and temperature for an ML-419/AMT-4 thermistor.

Bonded strain gages have come into general use in the last few years for measuring residual stresses in rock. This is accomplished by cementing strain gages to the rock under stress. A core drill is used to remove the rock surrounding the gage. If, for example, the rock is under compression, removing the core will relieve the compresssion, with corresponding deformation of the core. The strain can be measured directly with the gage, and if a sample of the material is placed in a testing machine the stress can be determined.

Bonded strain gages were used to a great advantage in construction of the Prospect Mountain tunnel in Colorado. It is estimated that 833,000 lb of structural steel were saved by the use of strain gages in this tunnel.[2]

Pressure: Since the theory of manometers and diaphragm-type instruments has been known for years, it will not be discussed here. The main objection to





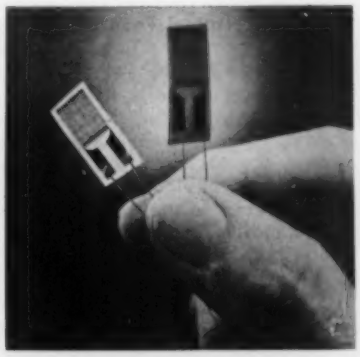


Fig. 4 (left)—Disk, rod, and bead thermistors with a humidity element. Fig. 5 (center)—Unbonded strain gage (Statham Instruments Inc.). Fig. 6 (right)—Bonded strain gages (Baldwin-Lima-Hamilton Corp.).

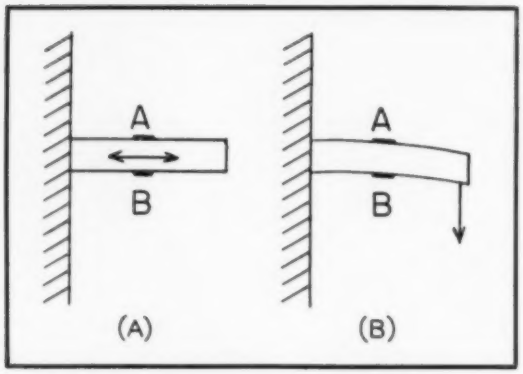


Fig. 7—Strain gages mounted on a bar or rod.

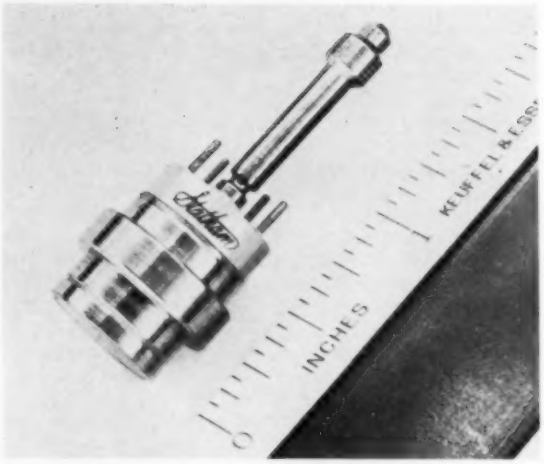


Fig. 8—Pressure transducer (Statham Instruments Inc.).

these instruments is that an electrical output cannot be obtained from either of them. However, with unbonded strain gages it is now possible to construct pressure transducers that have an electrical output and are capable of accurately measuring pressures from a few inches of water to thousands of pounds per square inch. If a pin from the center of a bellows is connected to an unbonded strain gage, the movement will be proportional to the area of the bellows. If one side of the bellows is vented to atmospheric pressure, it will measure gage pressure; if one side of the bellows is evacuated, it will measure absolute pressure. With connections to each side of the bellows, it is possible to measure differential pressure. Fig. 8 shows a pressure transducer manufactured by Statham Instruments Inc.

Flow: In the past, practically all flow measurements in industry have been made with either venturi or orifice meters. Since the flow measurement is dependent on differential pressure measurements across the venturi or the orifice, a direct connection can be made to pneumatic controls or recorders. However, if an electrical output is desired, a strain gage type of pressure transducer can be used to measure the pressure differential. The greatest disadvantage of orifices is that they are subject to wear, which changes the calibration. This is especially true if fluid contains suspended matter or abrasive material. Another objection to venturi and orifice meters is that a restriction must be placed in the line.

A new type of flowmeter has been placed on the market by the Foxboro Co. Fig. 9 is a cutaway view of a magnetic flowmeter that operates on the principle that an electromotive force is generated when a conductor is moved through a magnetic field. From Fig. 9 it is apparent that when a current flows through the coils, a magnetic field will result that is perpendicular to the direction of flow. If the flow of the fluid through the tube is considered as a series of thin disks, each disk can be thought of as a conductor moving through the magnetic field with a length equal to the diameter of the tube. Since the electromotive force generated by a conductor moving through a magnetic field is directly proportional to the strength of the magnetic field, the length of the conductor, and the velocity of the conductor through the magnetic field, any fluid flowing through the tube will generate an electromotive force. Since the length of the conductor is equal to the diameter of the tube and remains constant, if the strength of the magnetic field is held constant, then the electromotive generated is directly proportional to the velocity of the fluid. Thus when electrodes are inserted in the sides of the tube perpendicular to the direction of flow and to the magnetic field, the electromotive force at the electrodes is directly proportional to velocity of flow.

The present type of magnetic flowmeters requires that specific conductivity of the fluid must be at least 200 micromhos for the smaller pipe sizes. This immediately eliminates measurement of gases and hydrocarbons, since all types of measuring instruments require a small current. Measurement of fluids with lower conductivities can be placed in the same category as the measurement of the electromotive force of a cell with an extremely high internal resistance.

The main advantage of the magnetic flowmeter is that it measures the volume rate of flow so that the measurement is independent of viscosity, density, turbulence, or suspended matter. Examination of Fig. 9 also reveals that with the recessed electrodes there is no restriction placed in the line.

Position: Determining position usually involves measuring the movement of one object with respect to another—the thickness of material coming out of a rolling mill, the movement of a cutting tool on a milling machine or lathe, or the fact that a valve is open or closed. Liquid level measurements are made from the surface of the liquid to a reference point, which is usually the top to the tank.

Angular position of less than one revolution can be determined easily by connecting directly to a potentiometer shaft and measuring the resistance of the potentiometer or by using it in a bridge circuit as the legs A and B of Fig. 1 and connecting the sliding contact directly to the galvanometer.

In many applications the measurement of very small changes in position can be accomplished with linear variable differential transformers. These transformers are relatively small, mechanically simple, and very durable. They require negligible actuating force, operate in a wide temperature range, are not affected by pressure, and are completely free of friction.

Fig. 10 shows construction of the linear variable differential transformer, which consists of three equally spaced coils wound on a cylinder. When the

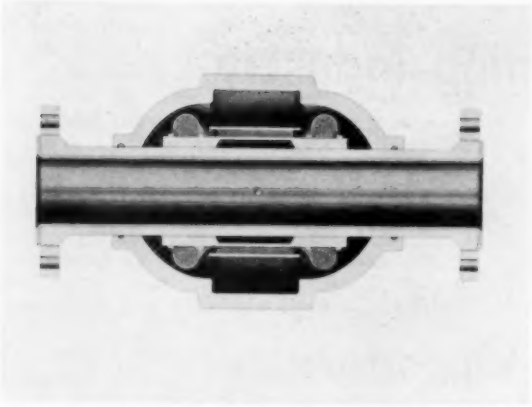


Fig. 9—Cutaway view of a magnetic flowmeter (Foxboro Co.).

primary or center coil is connected to an alternating current source, a voltage is induced in the two outer coils. Since the outer coils have the same number of windings and are equally spaced, the voltage across each coil will be the same if the core is exactly centered. If the core is moved in one direction, the voltage in the coil in the direction it is moved increases while the voltage in the other coil decreases. If the two secondary coils are connected so that the two voltages oppose each other, the output voltage is zero when the core is centered and increases linearly with movement of the core. Increase in voltage is the same regardless of the direction the core is moved except that the phase is shifted 180°.

Vibration: Vibration measurements are accomplished with a variety of transducers, depending upon whether acceleration, velocity, or actual displacement of the vibration is to be measured.

Referring again to Fig. 5, if the armature is considered as a mass M and the case is vibrated in the same plane as the elements, the transducer measures either acceleration or the displacement, depending on the calibration used.

If the transducer is to measure displacement, it is used as previously mentioned in the section on

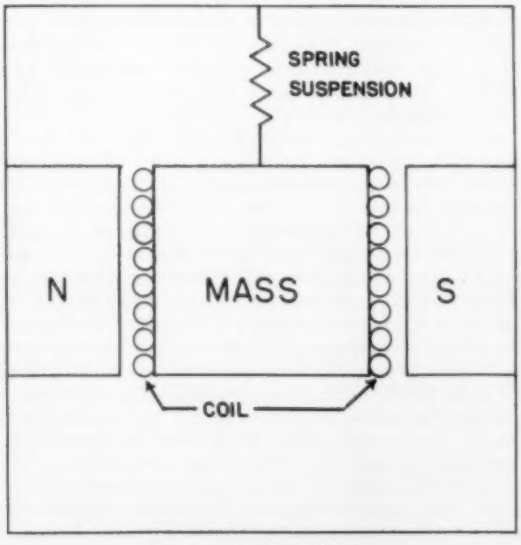


Fig. 11—Transducer design.

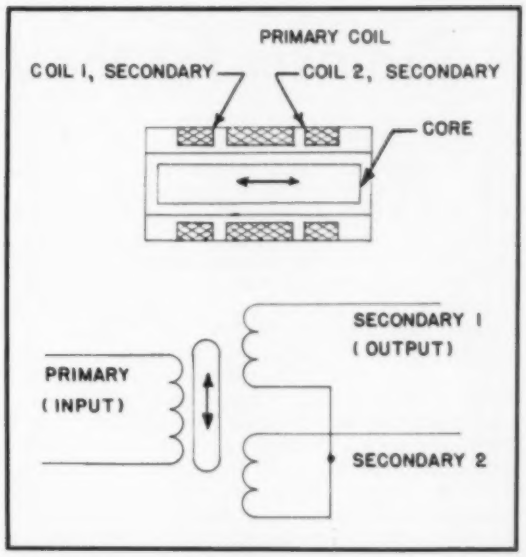


Fig. 10—Cutaway view and circuit of a differential transformer (Schaevitz Engineering).

unbonded strain gages. If it is used to measure acceleration, it is necessary only to remember that acceleration varies directly with applied force and inversely with the mass of the armature. Since the mass is constant, the acceleration is directly proportional to the applied force. To determine the output of a transducer mathematically, it is necessary to show all the resultant forces acting on the mass in the form of the differential equation

$$\frac{d^2y}{dt^2} + C\frac{dy}{dt} + \frac{K}{M}y = \frac{d^2x}{dt^2} \qquad [3]$$

where x is the motion of the body being studied, y the motion of the mass with respect to the case of the transducer, K the spring constant of the member supporting the mass, M the mass of the armature, and C a constant depending upon the type of damping used. For example, when the transducer is filled with fluid, C will depend upon viscosity of the fluid.

The most common method of measuring velocity of a vibrating member is with a transducer design similar to that in Fig. 11. A coil is wound around the mass as shown so that when the transducer is vibrated up and down, the coil will move through the magnetic field. Since the mass, the strength of the magnetic field, the spring, and the damping are all constant, output of the transducer is directly dependent on the velocity of the coil through the magnetic field. In many cases the velocity transducers are constructed with a permanent magnet acting as the mass and the coil is fixed to the frame.

Acknowledgments

The author wishes to thank the various companies that contributed photographs of their products.

References

[1] M. H. Aronson: A Counterattack on Anti-Automation Propaganda. *Instruments and Automation*, June 1955, vol. 28, p. 893.

[2] O. J. Olsen: Measurement of Residual Stress by the Strain Relief Method. *Quarterly of the Colorado School of Mines*, July 1957, vol. 52, no. 3, p. 183.

A Program for the Mining Industry

- Ideas
- Opportunities
- Incentives

by Richard M. Foose

WOULD you like to find a large new ore deposit next year? The answer is as obvious as the question is foolish. But perhaps the question does have some merit if we alter it slightly and ask: What are you doing about finding new ore? This one is more difficult to answer. Possibly you are doing nothing about finding new ore because you have proved reserves for many future years of production. Others may be investing some small percentage of time, effort, and money in mineral exploration, and reserves may be currently adequate, or inadequate, in terms of many future productive years. Still others may be engaged in large-scale mineral exploration programs involving large expenditures of time, personnel effort, and money.

In whatever category you may be, a final question might well be asked. Is your current mineral exploration program, or lack of program, consistent with the long-range needs and objectives of your organization and of the mining industry as a whole, and is it designed to stimulate the growth of the industry in future years, or is it only a short-range program in response to some current situation?

In terms of the mining industry's future, three things are perhaps needed more than just finding another ore deposit.

First, there should be increased generation and acceptance of new ideas by the industry.

Second, more favorable incentives should be provided for industry operation, both within the industry itself and by those external agencies that help control the overall economic environment within which the industry must function.

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Third, wherever possible a more consistent and less spasmodic approach should be made by industry toward its problems through its actions and policies, in an attempt to elminate the "feast or famine" aspect of mining and to strengthen its position for the future.

Need for New Ideas

Let us examine some of these premises to see if they are valid. Concerning the need for generating more ideas within the mining industry, there is no implication here that the mining people have been barren of new ideas. Certainly not! But within an industry that continues to face tougher and more challenging problems in ore finding and mineral technology year after year the environment for generating and recognizing the value of new ideas does not seem to be ideal.

A common experience of many talented young geologists who have gone to work for mining companies is to be placed on some routine geologic job and kept on it long past the time when it could possibly have value to them or the company from the point of view of "learning the business." I know personally two young geologists trained within the past 10 years who possessed unusual ability in their fields and who were so frustrated by the lack of flexibility of the mining organizations they worked for and by the impossibility of being creative in their jobs that one has left geology completely; the other is engaged in research with one of the petroleum companies. There is no quarrel here with the need to do routine jobs, but there is strong objection to the policy of sweeping all into a common mold without any system for recognizing individual talents and competencies and utilizing these when they are revealed.

Another common experience of able geologists and mining engineers alike is to be given wide latitude to work on some of the interesting problems that may be associated with a mine or a mining district but also to be faced with specific responsibilities dealing with mine development that are so demanding there is not adequate time to do more. For a man to have ideas but inadequate time to experiment with them is stultifying. In many cases adequate time could be achieved by a small adjustment in manpower allocation and assignment. Ideas are like living plants. They need to be nurtured in order to grow and to flower, and when they do their seeds create others. But if they are prevented from maturing time after time, ultimately they die, and worse, their source is dried up.

Finally, it seems to be common practice for mining companies to turn to outside help for the solution of both large and small problems. Thus the mining consultant often plays a critical role in maintaining the welfare of the company. Under ideal conditions he brings to the organization a fresh viewpoint, new ideas, and a freedom of approach and action that might not be possible from within. There is no objection, therefore, to the important activities and interests of the consulting geologist or mining engineer; obviously he is needed badly. But total dependence upon outside help and direction tends to be debilitating for the company. If there is no person or staff committed to the task of thinking of, planning for, and directing exploration and development then there will not be any reservoir of ideas and creativity within the company upon which to draw. Worse than that, there may be none to exercise able judgement on the ideas of others. It seems important, therefore, for each organization to create and maintain its own group, no matter what size, whose responsibilities will be concerned, at least in part, with the generation, assessment, and application of ideas to its own problems or to those of the industry.

More could be said about the need for developing ideas within the industry. But what about the need for more incentives?

Incentives for the Industry

Obviously a major incentive for attracting able young men into the industry is an organizational system flexible enough to recognize individual talent and to accept new ideas for trial.

Another incentive over which the industry itself has control has to do with research in all phases of the industry, including exploration, mining, beneficiation, and metallurgy. In this regard there have been many encouraging signs during the past 10 or 15 years. The amount of research in ore beneficiation and metallurgical practice has been increasing. Mining research, too, has made tangible strides. In the field of geologic exploration old techniques have been modified and new ones devised. Geochemical prospecting is essentially new. Photogeology and its application to field geology has proved to be a most valuable technique. Colored aerial photography in mineralized areas is a promising tool. Well established geophysical methods are now quite widely used by mining companies—a few years ago they were used almost exclusively by the petroleum industry. New geophysical techniques are being tried. Some, such as electromagnetic methods, are still somewhat of a fad. With all of this, however, there is still little or no research dealing with fundamental problems of mineralization, occurrence of ore deposits, or the physical and chemical character of ore-bearing solutions and of the earth's crust, to mention only a few.

Although the mining industry may claim to have invested more money in research programs than some other segments of the industrial economy, the record is not impressive. Quoted in terms of percent of sales, one survey of several industry types for the past few years reveals the mining industry lagging well behind the chemical, pharmaceutical, chemical process, and petroleum industries in terms of applied and basic research. During 1957 the mining industry spent less than 2 pct of total sales on research. By comparison, the chemical industry spent about 4 pct and the pharmaceutical industry 5 pct of total sales on research.

It is interesting to note the large sums spent on research dealing with many of the relatively new metals, such as titanium, germanium, and niobium, and the relatively small sums on research dealing with well established metals like copper, lead, and zinc. Much more attention shoud be paid to research on these older metals, especially in terms of possible new uses. Think of the impact that would be made on the lead or zinc industry if one or more important new uses were developed for these products. Conceivably the stimulus would be sufficient to create such a demand for these metals that this part of the mining industry would be restored to full operating capacity, with a corresponding favorable response in metal price. Research programs by the industry would provide a tremendous incentive for industry growth and well-being.

Another encouraging sign in the past decade has been the development of interests by many of the mining companies which go beyond the classical concept of mining one kind of ore and producing only one or two metals. These programs of diversification have created tangible incentives for outside interests to participate in the mining industry. For instance, the chemical process and petroleum industries have been participating more and more actively in mining during the last few years. Activities of this sort have been notably successful when the programs fitted the talents and competence of existing staffs and when the program has been compatible with the long-range objectives of those involved. It is true that in some cases programs of diversification have been overdone and bad mistakes have been made, but generally this process of hybridization and cross-pollination has had a salutary effect on the vigor of the industry.

Need for Improved Tax Environment

We have been talking about incentives that stem primarily from within the industry itself. What about those that arise outside the industry but help control the overall economic environment within which the industry must operate? Government must be made to recognize—and the mining industry must assume the responsibility for effecting this recognition—that the difficulties and costs of fiinding new ore deposits are mounting steeply and, therefore, the risks involved in exploration programs are very great. The national security as well as the health and vigor of the industry are affected by governmental policies dealing with taxes and cost depletion of mining properties. It is to be hoped that the following incentives will soon be made available to the entire

mining industry. They are essential to its welfare and future growth.

First, all exploration funds should be deductible under the Internal Revenue Code. New mines should be exempt from taxation for two or three years after the establishment of profitable operations.

Second, tax rates should be lowered to a maximum of 50 pct and tax computation methods should reflect any inflationary trend so as to eliminate capital confiscation.

Third, depletion rates should be increased to recognize the temporal character of the assets and to stimulate the flow of risk capital into more and more exploration ventures.

Fewer Fluctuations in Mining Research

It is not enough to consider only the need for ideas and incentives in the mining industry. Another factor should be examined: namely, the industry should cultivate a smoother, more consistent, and less spasmodic approach to its problems.

The mining industry is one of the oldest in the world. Before the beginnings of history it provided raw new wealth to the world for purposes of trade and use. As men learned to process and fabricate minerals, demand for them increased manyfold and the incentive for prospecting and discovery was created and strengthened.

Today the mining industry and the production of mineral commodities are fundamental to the growth and development of all nations except those few still existing on an agrarian economy. Historically the mining industry, and the vast array of mineral resources that have been produced by it, have provided the core and fabric of industrial growth in these nations. Those countries that have had the largest number and widest variety of mineral resources within their own boundaries have generally fared best. However, one need only point to the phenomenal development of a complex industrial economy in Germany both before and after World War II to recognize at once the possibility for growth and the precarious nature of this growth when it is dependent upon importation of essential mineral commodities.

In view of the antiquity of the mining industry, with its beginnings in earliest historic time, and the fundamental and increasing demand for mineral resources to support the developing industrial economies of the world, it is surprising that the mining industry today is not a good deal more sophisticated than it is in coping with its basic problems, such as mineral exploration. In fact, some would say the industry is naive. Why is this true and what might be done about it?

Several factors should be briefly mentioned. They are familiar to everyone. Nevertheless they merit repeating, if only to provide some background for understanding the industry today.

Spasmodic Nature of Mineral Exploration

Nearly all ore deposits are indeed non-renewable resources. When they have been mined out, they are gone. Unfortunately, some mining companies seem to ignore this obvious fact and do not conduct any search for, or even have staff or facilities devoted to the search for, new ore deposits until reserves are critically low. Then there may be an all-out exploration program involving considerable new staffing, new equipment, many consultants, and considerable reorganization. Such efforts are spasmodic in nature and likely to be launched without any internal backlog of thinking or history of research effort on which to base the new program of mineral search. Obviously such a program must get off to a slow start, perhaps even a poor one. Although this statement is somewhat generalized, everyone can think of examples that support it. This kind of activity is in accord with a "feast or famine" philosophy, and the industry as a whole cannot expect to grow on this basis.

Recall the situation regarding reserves of iron ore in the U. S. at the end of World War II, just 12 years ago. Reserves of iron ore, and especially high grade ore, had been drastically reduced. The next five years witnessed probably the largest concerted search for ore by the industry in its long history. The development of important deposits of iron ore in Canada, Venezuela, Liberia, the U. S. and other countries as well, resulted from the feverish activity generated in just a few years.

Between 1949 and 1954 there was frantic activity in the search for uranium ores, although it is only fair to point out that the romantic hysteria of that short era involved many others besides the mining industry itself. During the last two years we have observed the development of intense interest and activity in the search for ores of the reactive and high-temperature metals.

These spasmodic bursts of activity by the industry have certainly produced ore, and it might be argued that this is the way it ought to be done. After all, there are innumerable examples similar to these in the long and romantic history of mining—events such as the California and Klondike gold stampedes and the short feverish era when many of the porphyry coppers were developed. There will always be times of more intense activity in exploration and development by various segments of the industry. This is inevitable because of the new and changing demands for an ever-widening spectra of mineral raw materials and their products. But it is not necessary, or inevitable, to have depressed periods in which there is little or no research, exploration, or development between the bursts of activity, either for the industry as a whole or for major parts of it.

A train on a level track uses little power to move steadily ahead. But when the train is on a steep grade the engine must produce more power to keep the train moving. When the occasion demands it is good to have an engine on the train capable of generating the needed power as well as a crew that knows how to run it and apply the power—much better than having to build a new engine when the grade is reached or to call in a new crew that does know how to apply the increased power.

Challenging Problems of Mining Industry

This sounds simple and true when we talk about trains. Is it any less true when we talk about the future of an industry that each year faces tougher and more challenging problems than ever, problems such as beneficiation of lower and lower grade ores, mining at greater depths under more hazardous conditions, or seeking ore deposits hidden under alluvial and rock cover.

Consider the problem of seeking hidden deposits. Historically, most of the great mineral deposits and mining camps have been developed as the result of finding surface exposures of ore. Hence, prospecting and organized programs of mineral search have

found the comparatively obvious deposits with surface exposures. Until 1945, of the ore deposits that then constituted the nation's reserves, nearly all were initially exposed at the surface. However, the actual bulk of the reserves embodied in these same ore deposits had been developed by subsequent extensions of the original known ore, both by extending the ore boundaries at depth and in all directions and also by lowering the cut-off grade by improved technology. Since 1945 an increasing number of the newly found deposits have been completely hidden —not necessarily deeply buried, but unexposed at surface. Obviously the mining industry must plan to search for more and more hidden ore deposits in the future—for this is the kind that is left.

The industry as a whole, as well as the individual mining companies, will be in a better position to conduct such ore searching activities if they develop staff and facilities capable of carrying out programs of research that will cope with these problems. The scale and scope of such research activities should be established at a level that can be constantly maintained. They should not be subject to drastic alteration or cancellation due to management whims or pessimism engendered by falling metal prices. Like the train on the grade, such a research program could be stepped up when necessary. Such action would go a long way toward eliminating the spasmodic approach of these companies to their problems and insure the proper application of effort to specific needs as they arise.

Ideas, incentives, and a more consistent and thoughtful approach to exploration and development are three highly desirable goals the mining industry should seek. Achieving them, the industry may then expect to develop and grow more rapidly, perhaps, than ever before in spite of the challenging problems that characterize its future.

A Proposed Program

What can the mining industry do to achieve these desirable goals?

► First, it should create and support research activities within its own organization structure, each one appropriate in size and purpose to the plans and goals of the individual organization.

► Second, it should support, on an industry-wide basis, programs of fundamental research dealing with major problems in the earth sciences, such as geochemical research on the behavior of important chemical systems at elevated temperatures and pressures—a program that would advance significantly our knowledge about ore-bearing solutions—or programs of geophysical research dealing with fundamental physical characteristics of the earth's crust and individual rock types, with crustal temperatures, heat flow, and rock mobility. New knowledge on any of these subjects would greatly enhance our understanding of the nature and occurrence of ore deposits. Fundamental research of this kind may be and probably should be also supported in part by governmental agencies such as the National Science Foundation. However, unless the industry actively participates and even leads the way in the support of such research in our universities and research organizations, it may lose its free and competitive position in the economy and can hardly expect to avoid governmental incursions into its business, some of which may be restrictive.

► Third, the industry should give broader support to academic institutions engaged in the training and education of the industry's technicians, engineers, scientists, and leaders of tomorrow. And this means support for more than training in technical and scientific skills alone; it means support for the training of men with broad educational backgrounds who are as well grounded in the fundamental concepts of the humanities as they are in science and engineering disciplines. This would mean significant financial aid through scholarship programs and gifts to colleges and universities at the undergraduate as well as the graduate level and certainly much more support to the nation's smaller liberal arts institutions that continue to supply, as they have in the past, a majority of the leaders to our national life—and this in technical and scientific disciplines as well as in the humanities. We must not assume that adequate manpower with first-rate competence automatically will be available at the graduate level for advanced and specialized training or for the industry when it wants and needs it. To insure the availability of manpower in the right quantity and with top quality the industry must pay attention to its source. This means at the undergraduate college level and even in the high schools. Too many top students at the high school and college level never even consider mining, or geology, or related fields in the earth sciences as a possible future career because they have not heard of them or because the attractive and challenging possibilities of these careers have not been pointed out.

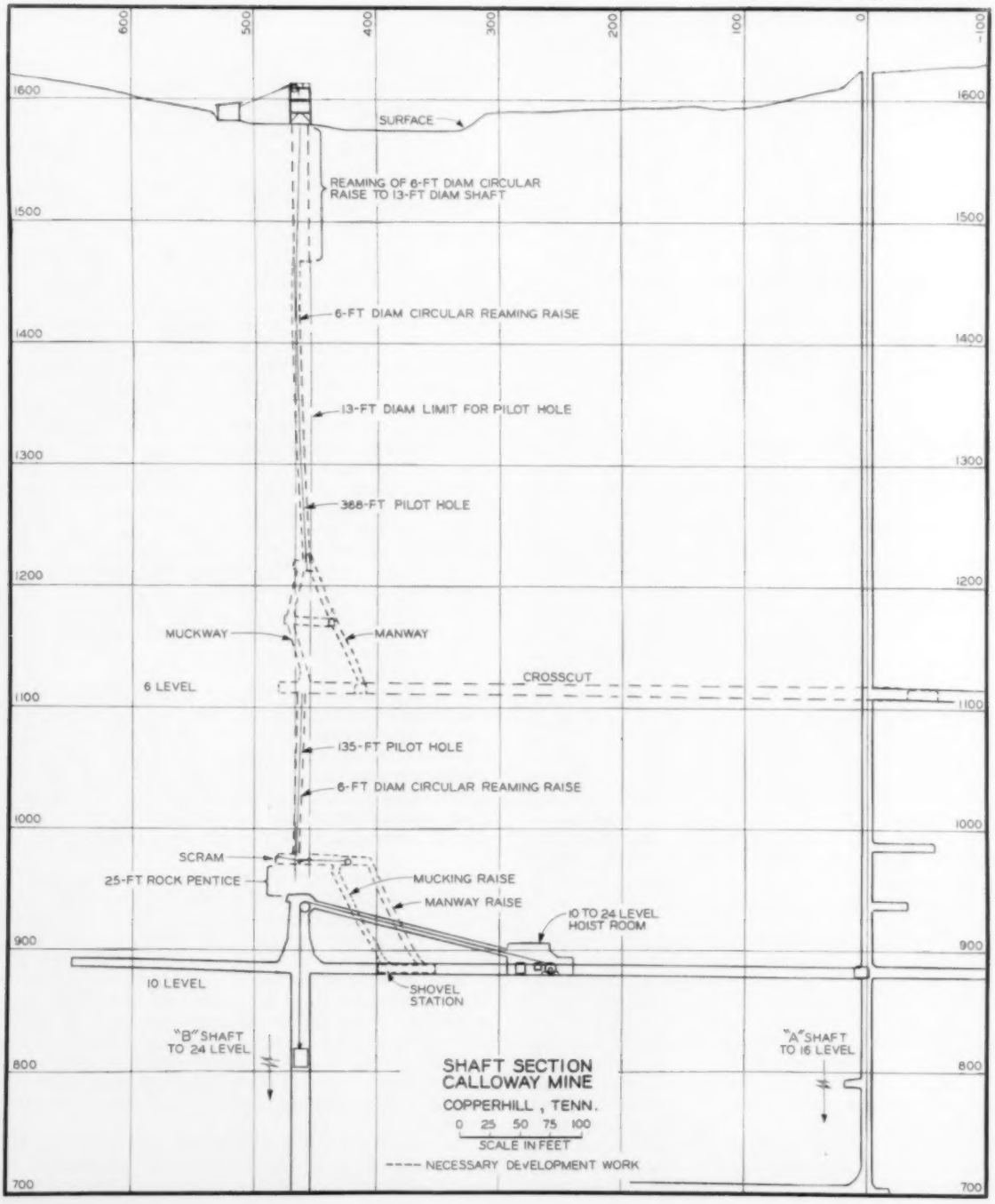
► Fourth, the industry should seek to create a realistic and favorable environment within which to operate at all levels of governmental interest. This will call for the continued and concerted effort of the industry to educate all concerned with the need for non-restrictive taxation and fair and incentive-creating depletion rates that will stimulate flow of capital into research and exploration programs.

► Finally, and probably most important, it is essential that a positive and progressive attitude be created and maintained throughout the industry which would provide the basis for the previously mentioned goals to be achieved. This attitude must be genuine and permeate the entire industry from top management through technical and scientific personnel to the men in the mine and mill. It cannot fluctuate like recent metal prices! Obviously such an attitude is not universal. Indeed from time to time there are major segments of the industry that are dominantly negative and restrictive in their thinking.

The future for the mining industry is challenging and bright, with all of its difficulties. Its horizons are limited only by as far as it wants to see.

Improved Pilot Hole Surveying Method Aids Shaft Extension

Fig. 1—Section through *A* and *B* shafts.



At Calloway mine an innovation in hole surveying held error to 1 ft per 354.5 ft of hole drilled

by R. Lee-Aston

CALLOWAY mine of Tennessee Copper Co. at Copperhill, Tenn., has been under development for several years. It has two shafts, the *A* shaft, 1336 ft deep from the surface to the 16 level, and the *B* shaft, lying 500 ft to the southeast and extending 1385 ft deep from the 10 level down to the 24 level.

A section through the two shafts, Fig. 1, shows the development work entailed by the proposal and the area involved.

The Problem: For operational reasons it was necessary to extend the *B* shaft from the 10 level to surface, and the pilot hole and raising method was chosen. This method had been used to extend the Company's Boyd manshaft from the 10 to the 14 level in 1954, but no satisfactory hole surveying method had been employed. In that instance, when the hole was located it was found to be about 8 ft from its calculated position. The success of this shaft extension method lies in the ability to keep the pilot hole within the proposed shaft diameter for nearly the entire length. The approximate 670 ft of extension distance in one hole was thought to be excessive because of deflection encountered locally in other core drilling. Since a connection between the two shafts, intermediate between the surface and the 10 level, would be required at some future date, the pilot hole drilling was done in two sections. This intermediate level was fixed at the 6 level and distances became 470 ft from surface to the 6 level and 230 ft from the 6 to the 10 level. A rock pentice of 25 ft was left temporarily in place just above the 10 level.

A hole surveying method was needed that would show hole deflection from the vertical down to 1°, or less. In the past the Maas compass method had been used locally for exploratory EX and AX holes, but for this hole it would not register the small changes in deflection which could take the hole outside the shaft diameter before it would be realized. Furthermore, the changes in bearing accompanying the small dip changes would be less accurate than desired.

Design of Necessary Hole Surveying Equipment: The hole was drilled with a 3⅞-in. bit. Designing showed that if the glass tube used for surveying were enlarged from the standard 1-in. diam. to a 3-in. diam—still utilizing the acid-etch principle—it would register change in hole dip nearly to a half a degree. With the hole size fixed at 3⅞-in. and the glass tube at approximately 3 in., designing a survey tube container to be let down into the hole remained a fairly simple task.

The bearing measurement, it was believed, would present more of a problem. The small Maas compass was no longer as readable, being literally lost in so large a tube. To obtain a larger needle more suited to the size of the tube, a 2⅛-in. needle and pivot were borrowed out of the Brunton compass. The pivot was to be placed in a hole in the compartment divider and cemented in place. Since the hole was to be vertical, or nearly so, the tilt of the needle should not be too much to interfere with its free floating. Should the tilt become great enough to hang up or become ineffective, the hole deflection would have been excessive, that is, great enough to take it out of the planned shaft compartment.

Fig. 2 is a sketch of the assembled improvised surveying instrument shown also in Fig. 3.

Standard local procedure has been to use two survey tubes at each survey point to act as a check on each other and to insure success in case one turned out badly. Each survey mechanism was placed in a water-tight brass tube and spaced 10 ft apart by brass tubing. There was 10 ft of brass between the upper survey and the steel drill rods. Wicking was used at each threaded connection on the survey container.

Because of the slight difference in diameter between the inside of the brass tube and the outside diameter of the glass, a wooden splint was placed alongside the glass tube to keep it perfectly erect within the brass container. To facilitate removing the survey tube, a string was put around the vertical dimension of the glass tube as it was lowered into the brass container. Care had to be exercised in placing the glass tube in the containers to prevent the needle from jumping off the pivot, and the driller was cautioned to let the survey rods down with ease so the needle would not be jarred during the survey.

Another necessary device was the goniometer for reading measurements (Fig. 3). Because the dip angle was so near to vertical, the dip ellipsoid etched on the glass tube was nearly a circle and the long axis of the ellipse harder to ascertain. The block or tube holder (also shown in Fig. 3) with parallel lines across the trough aided in reading the high and low points on the etched ellipse as it was rotated in the trough. This gave proper orientation in the home-made goniometer. Actually the parallel lines on the vertical board of the goniometer serve the same purpose. Rotation and sighting are more easily obtained in the block. With proper orientation established the dip and bearing of the hole are read.

Drilling and Surveying the Upper Section Pilot Hole: The local country rock is predominantly a metagraywacke of the Great Smoky conglomerate of the Ocoee series, with alternating bands of sericite and biotite schist.

Under a temporary headframe the surface hole was collared vertically by a Joy No. 22 drill with a 30-hp gasoline engine and hydraulic feed. A suc-

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Advantages of the Shaft Extension at Calloway

Operational plans previously drawn up called for ore from the lower part of the orebody to be hoisted to the 10 level and then carried by train underground for a mile to the Central shaft to be hoisted to surface.

During development, exploratory diamond drilling of lower levels revealed greater tonnage than had been anticipated. Consequently, studies were made that resulted in a plan to hoist the ore directly to surface at Calloway. The existing single-cage *A* shaft was inadequate, and upward extension of the *B* shaft from the 10 level to surface appeared the most feasible plan. This upward extension served four main purposes:

1) It eliminated transfer of ore on the 10 level from the Calloway mine to the Central shaft.

2) It enabled better rail car blending of ores from the different mines for the mill feed.

3) In the event of a Central shaft shutdown, the mill feed would not be reduced as sharply.

4) In permitting the use of *A* shaft as a ventilating shaft, it simultaneously solved a ventilation problem.

cessful survey was made at 170 ft and the hole was found to have a 4° deflection from vertical. The hole bottom was at 186 ft and a plot of the hole showed it to be just leaving the 13-ft shaft diameter. A new hole had to be collared. By working with the measured amount of deflection and curvature in this first hole, it was possible to collar a second hole 7 in. southeast of the theoretical center of the shaft. This hole was given a slight compensating inclination, being 2°-40′ down dip into the hanging wall of the bedding. Using the curvature found in the first hole it was anticipated that at a depth of 150 ft the hole would come close to the shaft perimeter, being nearly vertical at that point, and then turn and incline to the opposite side.

The hole was surveyed at 50-ft intervals and drilled to a depth of 368 ft. At that point the bottom of the hole was calculated to be 0.95 ft inside the shaft section. This was considered successful, as a raise could be put up the remaining distance to intersect the hole. The bottom survey showed the hole to have a deflection of 5.25° from vertical at that point. The hole was located in subsequent development work and found to be 12 in. off from the plotted point at that same depth. Fig. 4 shows the deflected sections of the abandoned and successful holes in the theoretical shaft section, as well as a plan view of the 368-ft hole.

Vibration of Drill Rods—Causes and Remedies: Only 10 ft of 3⅞-in. guide rod and 100 ft of N-size rods were available at first. When these were followed by A-rods the vibration of the string became so excessive that it prevented further drilling. This accounts for the rapid deflection of the first hole.

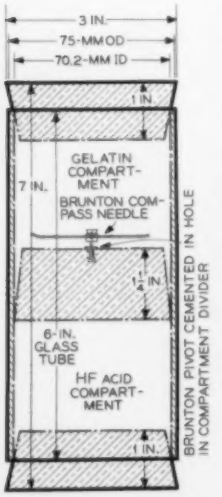
It is known that vibration caused by undersize rods is a factor that can be controlled by the operator. Some of the remedies recognized are:[1]

1) Ferrules and guide rods or drill collars above the core barrel.
2) Core barrels with welded metal ribs.
3) Drill rods of maximum size for the hole being drilled.
4) Couplings built up to the maximum diameter by ribs, inserts, or hard surfacing methods.
5) Sharp bits.

The first attempt to reduce this effect of vibration on the first hole was the design of a 3¾-in. diam guide ring to be used on the couplings between the A-rods. A sketch of this collar, which by itself proved unsuccessful, is shown in Fig. 5.

Other recognized remedies were adopted in drilling the second hole and ultimately contributed to its success. Thirty more 10-ft lengths of N-size rods were used. Specially built couplings were made for the N-rods. Victorite, a hard metal, was used as ribbing to build up the outside diameter from 3½ to 3 13/16 in. This type of coupling is illustrated in Fig. 6. A similar coupling with Victorite ribs was made to fit the top of the core barrel. All these measures—together with frequent bit changes and light drilling pressures—were successful in reducing vibration and rapid hole deflection.

Drilling Statistics: The core was temporarily stored in 14-ft troughs made of planking until logged by a geologist, and then it was discarded. Core recovery for the 186-ft abandoned hole was 98.17 pct and for the successful hole 94.29 pct.



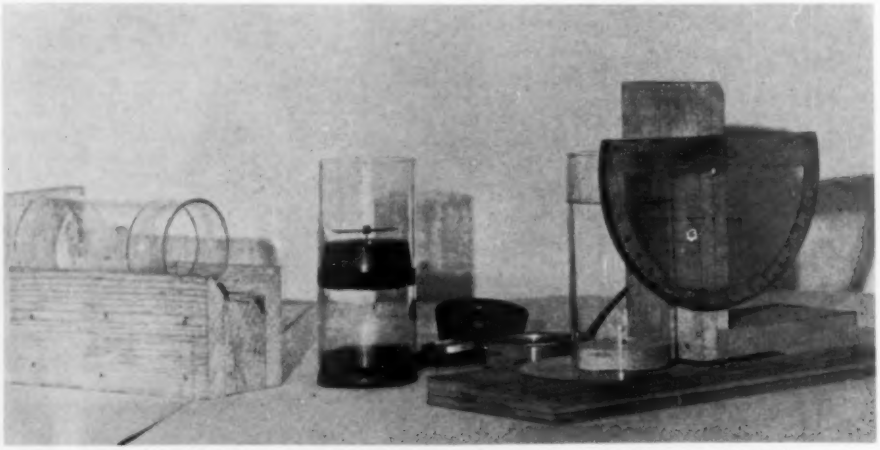


Fig. 2 (left)—Improvised hole surveying instrument. Fig. 3 (right)—Goniometer, tube holder, and assembled surveying instrument.

Plans and Sections Show Drillhole Deflection

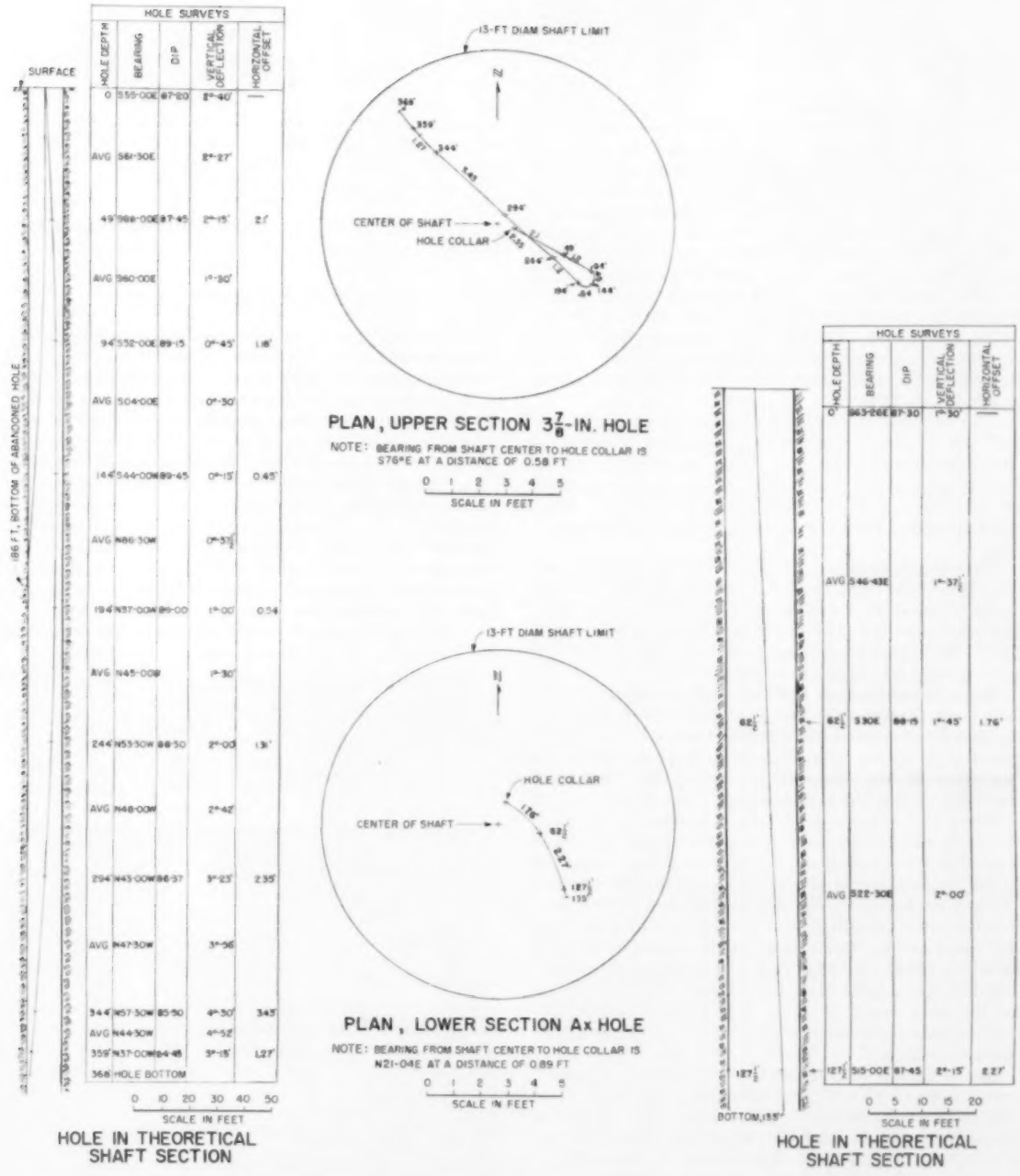


Fig. 4—At left and upper center, plan and deflected section views of upper section pilot hole. At right and lower center, plan and deflected section views of lower section pilot hole.

Twenty-six machine shifts were worked by the drill crew on the first hole before it was abandoned, making an average of 7.15 ft per shift. Footage for the 3⅞-in. bits used on this hole varied from a low of 6 ft to a high of 111 ft and averaged 36.2 ft per bit. The rock was considerably harder the first 75 ft than in the remainder.

In drilling the second hole 35.5 machine shifts were worked, averaging 10.66 ft per shift. This included time for hole surveying and repairs to the drill. Footage per bit was 18.4.

Carbon and labor costs for the 3⅞-in. holes are given in the table on the following page.

The pilot hole for the lower section had only about a 135-ft section to traverse, and very little deflection was anticipated, as the rock type in the 6 and 10 level crosscuts was the same as that in hole No. 1.

Costs for 3⅞-in. Drill Holes

Item	Cost for 186-Ft Hole, $	Cost for 368-Ft Hole, $
Carbon for hole	334.20	1336.80
Carbon per foot	1.80	3.63
Labor for hole	783.59	1117.82
Labor per foot	4.21	3.04
Total (carbon and labor) per foot	6.01	6.67

It was decided that for this shorter lift it would be more economical to drill an AX hole and ream it to the 3⅞-in. size with a series of reamers. This hole was collared at 87½ E down dip of the stratum. The purpose of collaring down dip was to prolong the hole leaving the shaft section, since past drilling experience in local formations has demonstrated that the hole will seek an orientation normal to the dip of the bedding. Surveys taken at 62.5 ft and 127.5 ft showed that the hole had not yet righted itself to the vertical as had been anticipated, but it was still within the shaft limit. The trace of this hole is shown in Fig. 4.

The original clip connection between the cable and the drilling platform had been used in the 1954 Boyd manshaft extension. This connection, which had to pass through the pilot holes, was redesigned at this time to pass through the 1⅞-in. AX hole, consequently, reaming to 3⅞-in. became unnecessary.

This 135-ft hole was drilled with an air-powered Joy HS-15 in eight machine shifts, at an average 11.68 ft per shift. Footage per bit used was 8.4. Carbon cost per foot was $2.30 and labor cost per foot $3.31. The latter figure includes time for moving in, setting up, and hole surveying.

Mine Development: By the time the 3⅞-in. hole had been drilled from the surface, an 8x8-ft crosscut 543.5 ft long had been driven on the 6 level from the *A* shaft to the *B* shaft location in preparation for the lower section pilot hole drilling site. Development work the shaft extension is shown in Fig. 1.

When the 3⅞-in. pilot hole had been completed to 368 ft and the location in the shaft section determined by hole surveying, a 5x5-ft manway raise 118 ft long was driven from this crosscut to the bottom of the pilot hole location just outside the shaft limit. A short 4x6-ft subdrift was driven 35.5 ft from this raise across the theoretical shaft section. At this point, as shown in Fig. 7, the left rib was slabbed and the pilot hole was intersected by a drillhole for the next round at 17 in. Fig. 9 shows the actual and calculated positions of the pilot hole for the same elevation.

The muckway raise from the 6 level shaft location was driven in two lifts, as may be noted in Fig. 1. The raise to the first lift was driven 50.5 ft with a connecting 4x6-ft subdrift of 40.5 ft between the two raises. The raise to the second lift was driven 41.5 ft up to the level of the hole intersection.

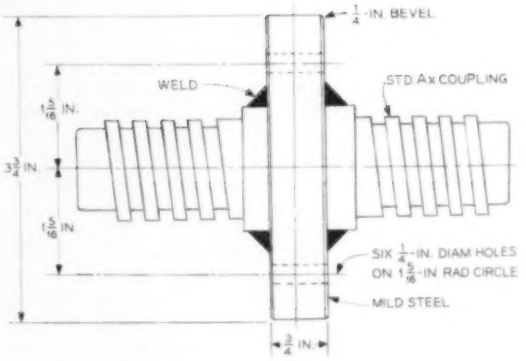


Fig. 5—Guide ring for AX coupling.

To insure that *B* shaft production from the lower levels would not be interrupted at 10 level throughout the extension work, a solid rock pentice of 25 ft was left between the top of the existing *B* shaft and the start of the upward extension. This pentice was to be removed last. A scram subdrift was driven at the top of the pentice after two raises had been driven from the 10 level to the scram drift elevation. One raise, a manway, was driven 104.5 ft; the other, a muckway, was driven 86.5 ft. The scram subdrift between the raises was driven to accommodate an air-powered slusher with a 36-in. blade for disposal of rock to a shovel station below on the 10 level. An Eimco 21 shovel was used to load into 6-ton cars and the waste rock was carried to an old stope on the 10 level in an adjacent orebody and dumped.

Pilot Hole Raising: A single-drum electric-powered hoist was placed on the 6 level and a ¾-in. nonrotating steel cable with a 6-ft steel probe end was lowered through the pilot hole to the scram subdrift at the top of the pentice. A drilling platform (Fig. 8) locally called a *birdcage* was fastened to the cable and hoisted daily to the face for the crew to drill out a 6-ft diam raise round. A telephone connection was used between the hoistman and the drillers on the birdcage. Two Ingersoll-Rand R48 stoping drills were used on the cage.

Using 1⅝-in. detachable carbide inset bits with 1-in. hexagonal steel, a two-man crew drilled 32 rounds in 462 manhours, averaging 4.19 ft in a total of 134.0 ft.

On completion of the circular raise to the 6 level, the birdcage was disassembled and taken up the manway raise to be reassembled on the second sublevel above the 6 level. The upper section raising on the pilot hole started here. A single-drum electric hoist was installed on the surface in a temporary hoist building. The circular 6-ft diam raise was driven 353 ft in 52 rounds, or 692 manhours for the two-man crew, at an average 6.97 ft per round.

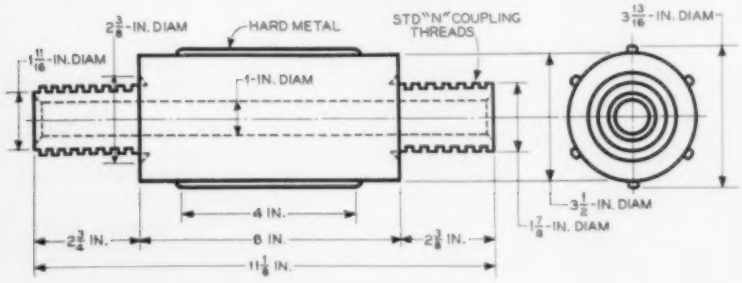


Fig. 6—Special coupling for N-size drill rods.

Conclusions

It is axiomatic that success of the pilot hole method in shaft extension lies in the ability to keep the hole within the planned limit of the shaft compartment, but an accurate hole surveying method is equally important.

Although the profession is not lacking in surveying methods, many are adaptable only to the larger holes. The mechanism is usually complex and expensive, particularly when it is usable in holes of less than 4-in. diam.

This use of the Brunton needle and pivot precludes its application to holes where maximum deflection may be greater than 10° to 12°. This apparatus can be utilized only where controlled vertical drilling is required. Since pilot hole drilling in shaft extensions falls in this category, the obvious merits of this surveying mechanism are its relative simplicity, low cost, and apparently reasonable accuracy.

It is known that drill rotation in vertical holes, even in homogeneous rocks, tends to produce a clockwise spiral in the drillhole.[2] Since the problem here was vertical control rather than directional control, that is, to keep within the cylinder of allowable limit, it may seem that the drift in the vertical plane is of greater concern than the azimuth. It must be granted, however, that the closer the trace of the hole is recorded, the less troublesome it will be to locate the hole bottom. This obviates the use of a dip survey alone.

The results at Calloway mine show a 1-ft error in 354.5 ft of hole, comparing favorably with the published results of a survey attesting the accuracy of a well survey method.[3] In this instance a Sperry-Sun gyroscopic well surveying instrument was used to locate the bottom of an 8-in. diam churn hole 1245 ft deep. The error was 3 ft in 1245 ft.

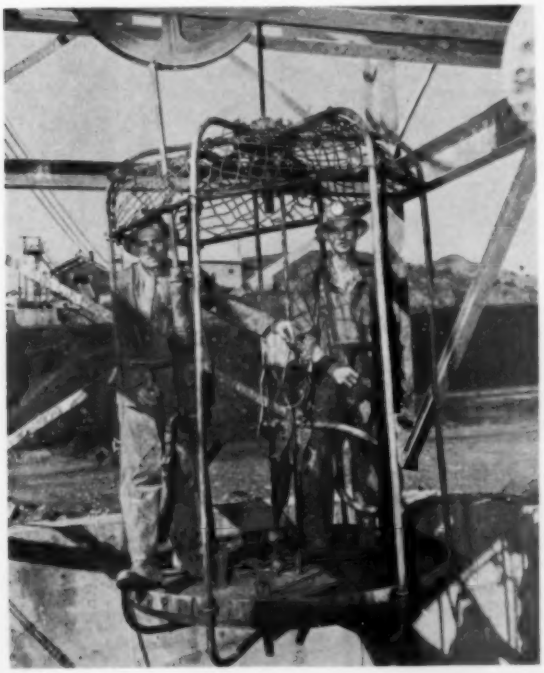


Fig. 8—*Birdcage* used in raising on pilot hole.

13-FT DIAM OF PLANNED SHAFT
DRILLHOLE INTERSECTING THE PILOT HOLE AT 17 IN.
N
CENTER OF "B" SHAFT
MEASURED LOCATION OF HOLE AT ELEVATION 1217 FT
12-IN. ERROR
CALCULATED LOCATION OF HOLE AT ELEVATION 1217 FT (HOLE DEPTH 354.5 FT)
SECOND SUB-LEVEL ABOVE 6 LEVEL, FLOOR ELEVATION 1214 FT
0 1 2 3 4 5
SCALE IN FEET

Fig. 7—Plan view of location of pilot hole in subdrift.

The spiral deviation of the hole caused by the drilling rotation and the dipping strata are factors over which there is little or no control. However, in the latter case, compensation for the strata was made by collaring slightly down dip to allow the hole to orient itself normal to the bedding.

The treatment for keeping hole deflection at a minimum was nearly exhaustive, although even more frequent bit changes might have increased the total depth of usable hole somewhat. By using deflecting wedges it would probably have been possible to drill the 470-ft lift successfully, or even the entire 670-ft length. Deflection from the upper hole's near vertical position at 150 ft downward averaged 1° 10′ per 50 ft drilled. With a maximum possible correction of 1° 30′ for each wedge used, about seven wedges would have been necessary to reach the 10 level and at the same time remain within the perimeter of the shaft. Unfortunately wedging is expensive, yet when it is considered from the outset, more than one attempted hole is unnecessary.

Mining requirements in this case made it practical to drill the pilot hole in two parts. Had it not been necessary to connect the two shafts on the 6 level much of the development work could have been eliminated and a one-hole set-up on surface would have gone through to the 10 level.

Acknowledgments

This article was written while the author was in the employment of Tennessee Copper Co. The writer greatly appreciates permission from the management to use maps and data and also expresses thanks to H. F. Kendall, superintendent of mines, and D. R. Wagner, chief mine engineer. Their suggestions and constructive criticisms were of great value.

References

[1] J. D. Cummings: *Diamond Drill Handbook*, 2nd edition, 1956, p. 71.

[2] Ref. 1, p. 427.

[3] S. H. Williston: An Unusual Test of the Accuracy of Well-Surveying Methods. *AIME Trans.*, October 1950, vol. 187.

Manufactured Sands Successfully Used in Grouts

James M. Polatty

FOR structural as well as economic reasons, sanded grout rather than neat cement grout should be used wherever possible. The chief drawback in using sanded grout mixtures, however, is the tendency of the sand to settle out, causing problems in pumping. Manufactured sands have not been used in sanded grout because it has been assumed that their irregular particle shape would add to the pumping difficulties.

The Concrete Division of the Waterways Experiment Station in Jackson, Miss., has conducted a comprehensive investigation of grouts containing both natural and manufactured sands. In the study of manufactured sand grouts an investigation was made of physical characteristics, ease of pumping, and the effects of adding certain mineral fines. The amount of material passing 100 mesh ranged from zero to 25 pct. Results were compared with test results for natural sand grouts.

Two manufactured sands were used, a limestone of 2.67 sp gr from a commercial quarry in Tennessee and a trap rock (diabase) of 2.90 sp gr manufactured in the laboratory from rock obtained from a commercial source in Connecticut. It was believed that selecting two sands of different specific gravity and other physical characteristics would provide an approximate yardstick for appraising the characteristics of grouts containing sands manufactured from other types of rock. To complete the range of variables, three gradations, (**A**, **B**, and **C**) of each of the two types of sand were test-pumped:

Mesh	Gradings, Cumulative Percent Passing		
	A	B	C
16	90±1	90±1	99±1
30	67±5	70±5	75±5
50	22±5	30±5	41±5
100	0±2	10±1	25±2

The percentages of each of the three gradations passing 100 mesh were: **A**, a nominal 0 pct; **B**, 10 pct; and **C**, 25 pct.

Effects of added mineral fines on pumping characteristics of the grouts were determined by tests of mixtures made with both the manufactured sands containing no fines (**A** gradation) by replacing a percentage of the cement with commercially available fly ash or loess from the Vicksburg, Miss., area.

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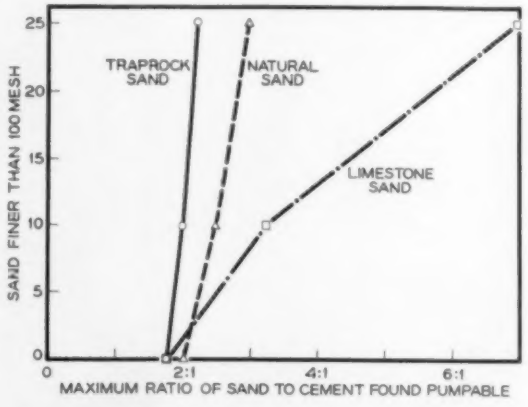
Test Program, Equipment, and Procedures: The investigation consisted of pumping tests to determine whether or not a selected combination of materials could be pumped. Tests were made with the same combinations to determine time of setting, amount of bleeding, and compressive strength of the grout mixtures.

After the combinations were selected, materials were thoroughly mixed in a paddle mixer and circulated through an air-powered grout pump back into the mixer. Tests were run to insure that the workability of the mixture was within the limits of the program, and necessary adjustments were made. The grout was next circulated through 200 ft of ¾-in. hose, coiled in a 5-ft radius that included a vertical loop rising 13 ft above the pump. Pumping was stopped for 15 min to determine whether enough sand in the mixture would stay in suspension during the delay period to allow resumption of the pumping operation. If the mixture could then be recirculated, it was judged to be pumpable. The limit of pumpability was therefore the maximum quantity of sand that could be pumped. Three batches of each mixture regarded as representing the limits of pumpability of each combination tested were test-pumped. Data were obtained during these tests on loss of workability during pumping, the line pressures, pump speed, and discharge rates both before and after the delay periods.

After the pumping tests were completed, the initial and final time of setting, the percent bleeding,



Limestone fines permit greatest increase in sand content of pumpable grouts.

and the compressive strengths of the cubes at 7 and 28 days were obtained.

Test Results for Limestone Sand: It was found that the limestone sand having the **A** gradation, that is, a nominal 0 pct passing 100 mesh, could be pumped successfully when the sand/cement ratio of the grout did not exceed 1.75 (1.75 parts sand to 1 part cement). However, 3.25 parts sand to 1 part cement could be pumped when the percentage of sand was increased to 10 (**B** gradation). When the amount of sand passing 100 mesh sieve was increased to 25 pct (**C** gradation) 7 parts sand to 1 part cement could be pumped.

When fly ash or loess was added to grout mixtures containing limestone sand of **A** gradation, the sand-carrying capacity of the mixtures was increased. With an addition of 1 part of either of these materials to 1 part cement, it was possible to pump 4.5 to 5 parts sand.

Test Results for Trap Rock Sand: In tests of mixtures containing the trap rock sand, with 0 pct passing 100 mesh (**A** gradation), it was found possible to pump 1.75 parts sand to 1 part cement. When the −100 sand was increased to 10 pct (**B** gradation), it was possible to pump 2 parts, and with 25 pct of −100 (**C** gradation), 2.25 parts sand could be pumped.

Adding 1 part fly ash to the trap rock sand of **A** gradation increased the sand-carrying capacity of the mixture to 4.5 parts.

Comparison of Pumpability of Natural and Manufactured Sands: Previous tests had revealed that it was possible to pump 2 parts natural sand having 0 pct passing 100 mesh (**A** gradation), 2.50 parts with 10 pct −100 sand (**B** gradation), and 3.00 parts with 25 pct −100 sand (**C** gradation).

Factors Affecting Sand-Carrying Capacity of Manufactured Sand Grouts: In the limestone sand tests, the effects of the two admixtures tested on the sand-carrying capacity were not appreciably different, although the apparent specific surface of the fly ash is almost twice that of the loess. Tests of limestone sands containing various percentages of −100 sand revealed increased sand-carrying capacity of the grouts, although both the fly ash and loess were considerably finer than the fine limestone sand.

As in the grouts made with limestone sand, increased percentage of trap rock sand finer than 100 mesh also increased the total amount of sand that could be used in a pumpable grout. However, the increase in sand-carrying capacity was relatively small, especially when compared to that of the grouts made with limestone sand, which indicates that the trap rock finer than 100 mesh was not as efficient as limestone in promoting pumpability. The surface area of the trap rock fines was much less than that of the limestone fines.

The addition of fly ash to the trap rock sand with essentially no material finer than 100 mesh gave results similar to those obtained in the limestone sand—fly ash tests.

The amount of both limestone and trap rock sand of **A** gradation that could be incorporated in a pumpable grout was found to be 1.75 parts to 1 part cement. The fact that identical amounts were found pumpable appears to eliminate differences in specific gravity, 2.67 for the limestone and 2.91 for the trap rock, as an element influencing pumpability in these tests. The fact that less trap rock sand containing 10 and 25 pct of material finer than 100 mesh could be pumped than was the case with limestone sand appears to be a function of the relative surface area of the limestone and trap rock fines. It is believed that had the trap rock fines been as fine as the limestone fines the pumpability of the trap rock sand would have compared more favorably with that of the limestone sand.

When a percentage of fly ash was added to supply fines to the trap rock sand having no −100 material, there was little difference in the pumpability of the limestone and trap rock sand grouts.

It is also possible that the surface texture of the limestone fines increased pumpability because, although the limestone fines had a smaller surface area than the fly ash or loess, pound for pound they appeared more efficient than either fly ash or loess in promoting pumpability.

Factors Affecting Setting Time, Bleeding, and Compressive Strength of Grouts: No wide range in either the initial or final time of setting occurred in or between the mixtures tested. There was a slight increase in setting time for those mixtures containing fly ash and loess as compared to those with no mineral admixture.

Bleeding of all the mixtures was slight; however, bleeding of the mixtures with trap rock sand was about twice that of the limestone sand mixtures. Addition of fly ash and loess reduced the bleeding slightly in the limestone sand mixtures but had very little effect on the trap rock sand mixtures.

In general, the compressive strengths of all the mixtures containing similar material were functions of their water content. The mixtures containing fly ash showed a slightly higher strength at 28 days than did mixtures with comparable water contents without fly ash, probably owing to the pozzolanic action of the fly ash. As was to be expected, the mixtures containing trap rock sand had a higher compressive strength than those made with limestone sand.

Conclusions

The conclusions derived from this investigation are based on the tests made with the equipment and materials described; somewhat different results might be obtained with other equipment. Also other mineral materials with different surface chemistry might, with similar granulometric characteristics, exhibit different properties when incorporated in portland cement grouts. However, the following conclusions are warranted:

1) Sands manufactured from limestone and trap rock can be used successfully in sanded grouts.

2) The specific gravity of the sand has little or no effect on the pumping characteristics of the grout.

3) Both fly ash and loess are effective in promoting pumpability and can be used to correct deficiencies in sands containing no −100 material.

4) Although the specific surface of the limestone fines used in these tests was somewhat lower than that of fly ash or loess, pound for pound it is more efficient in promoting pumpability.

5) Trap rock fines, being relatively coarse, were not as efficient as fly ash or loess and are much less efficient than limestone fines in increasing sand-carrying capacity.

6) Setting time increases slightly when fly ash and loess are added.

7) Bleeding was negligible for all the mixtures.

8) Compressive strength varied with water content but that of the mixtures containing fly ash was slightly higher at 28 days.

Four Iron Ore Agglomerating Techniques

Gradual depletion of high-grade Lake-Superior iron-ore deposits directed attention to the beneficiation of marginal and low-grade ores. Beneficiation processes—either flotation or magnetic—must be followed by agglomeration to produce pellets of sufficient size for blast-furnace charging. Two distinct techniques have been developed for hardening such pellets: the traveling grate and the shaft furnace.

The Traveling Grate—Updraft

Hardening Specular—Hematite Pellets

by Donald C. Violetta

LIMITATIONS of the sintering process as applied to the agglomeration of fine iron-ore concentrates are related directly to the sizes and aggregating properties of the ore particles. A normal sintering mixture is composed predominantly of material which ranges in size from ⅝ in. to 100 mesh, whereas concentrate is composed of material which ranges in size from 100 mesh to less than 10 μ. Unless the concentrate has high aggregating properties, it is quite impervious to a gas stream and, as such, inhibits the capacity and operability of the conventional sintering process.

Material has Poor Aggregating Properties

Aggregating properties, in this case, may be defined as the ability to form small agglomerated fragments or accreated masses by a normal mixing action, and the ability to maintain these shapes during drying and firing. Coarse-screened ores are a natural aggregate, and fine, slimey ores have good aggregating properties. However, specular-hematite flotation concentrate has a very low tendency to aggregate, due to its particle sizes, shapes, and surface chemistry and, as such, is readily air borne in a gas stream when dry.

Reports from the Rouge plant[1] of Ford Motor Co., where Humboldt specular-hematite concentrate is used in the sinter mix, have shown that a good quality sinter could be produced at high tonnages with 30 pct of the ore mix as fine concentrate. An increase in the amount of concentrate usually resulted in higher vacuums, lower windbox temperatures, and reduced tonnages.

Sintering Trials are Unsatisfactory

Laboratory studies at The Cleveland-Cliffs Iron Co.'s Research Laboratory have shown that sinter mixes containing 100 pct specular-hematite concentrate must be combined with at least 60 pct returns to produce good quality sinter, free from dust and unfired material. Batch sintering tests have shown this type of mixture would produce only 0.77 long tons per sq ft per day of +⅛ in. sintered material.

The aggregating properties of specular-hematite flotation concentrate may be increased with the addition of such binding agents as bentonite clay. However, with the addition of 0.5 pct bentonite to the concentrate, it required 50 pct returns to obtain a permeable bed and produce a favorable quality sinter. This addition of bentonite increased the capacity to only 1.01 long tons per sq ft per day of +⅛ in. sintered material. The addition of limestone to the ore mix did not increase the capacity of the sinter tests.

Based on a paper by DONALD C. VIOLETTA, Pyrometallurgist, The Cleveland-Cliffs Iron Co., Ishpeming, Mich.

Shaft-Furnace Shows Little Improvement

In view of the limitations of sintering as applied to specular-hematite concentrate, The Cleveland-Cliffs Iron Co. directed its research program toward pelletizing. After studying the pelletizing problem and having preliminary tests conducted at the University of Minnesota's Mines Experiment Station, Cleveland-Cliffs became directly interested in the shaft furnace as a method of agglomeration and constructed and operated a 1-ton per hr pilot plant. The plant was operated from 1950 through 1952 with favorable results obtained when pelletizing natural magnetite, but several operating difficulties were encountered when pelletizing specular-hematite concentrate. It was difficult to maintain a uniform combustion zone in the furnace, because all the heat had to be provided by an external fuel. This caused hot and cold areas to appear in the combustion and cooling zones of the furnace. The higher temperatures required to pelletize hematite and the heat transfer problem increased the clinkering tendency in the furnace, which disrupted uniform gas flow and produced a serious discharge problem.

Attention Directed Toward Updraft Furnace

Because of the operational limitations of the shaft furnace for agglomerating pellets of specular-hematite, the application of a traveling grate was the object of the pyrometallurgical research at Cleveland-Cliffs' Research Laboratory from July 1952, until the initial startup of the Eagle Mills pelletizing plant in September 1956.

There are two fundamental methods of firing green pellets on a traveling grate. The essential differences between the two methods are related to the direction of the gas flow and manner of bed feeding. Preliminary research on the downdraft method revealed that the drying phase of firing allows moisture to condense on the bottom layer of

green pellets, and factors of gravity and pressure cause these pellets to mush into a congealed mass which is impervious to a gas stream. This condensation phenomenon places limitations on green pellet moisture content and workable bed depths. In the downdraft process, the bed depth is defined and critical, but in the updraft process the bed depth can be applied in incremental layers, at discretion, based on the progress of the firing cycle.

A Number of Advantages Shown for Updraft Firing

The various departures involved with firing by the updraft method rather than the conventional downdraft method provide several distinct advantages, as follows: 1) There is no apparent limit of the maximum bed depth; 2) The combustion zone is the greatest source of dust, and when this is continually covered with wet pellets from stage feeding, the wet masses continually act as a dust filter; 3) Individual balling capacities are a fractional part of the traveling grate capacity, hence a specific balling device can form specific sizes of pellets, with particular quantities of fuel, and this charge can be placed in a specific location in the pellet bed; 4) It is possible to conduct all operations of firing, such as drying, preheating, ignition, combustion, recuperation, and cooling within the bed simultaneously; 5) The upward vector of draft imparts a semi-fluid state to the pellet mass which opens bed voids and prevents restrictions of gas flow; 6) The grate bars are never in contact with combustion products, hence are always the same temperature as the updraft stream of air; and 7) Bed pressures induced by pellet weight and compaction tend to be counteracted.

Conclusions Drawn from Laboratory Tests

The results obtained from approximately 500 laboratory batch firing tests provided the following general conclusion for updraft firing. These results were used as a guide when designing the Eagle Mills pelletizing plant.

1) Specular-hematite flotation concentration consists of small micaceous flakes which range in size from 48 mesh to about 5 μ and are coated with a film of flotation reagent. This hydrophobic film of flotation reagent repels water from the mineral interface; the micaceous texture tends to cause the particles to plate on one another rather than key and interlock; and the absence of substantial quantities of -5 μ material does not allow the particles to compact readily. As these three factors are important to the formation of a stable green pellet, specular-hematite concentrate is one of the most difficult materials to ball.

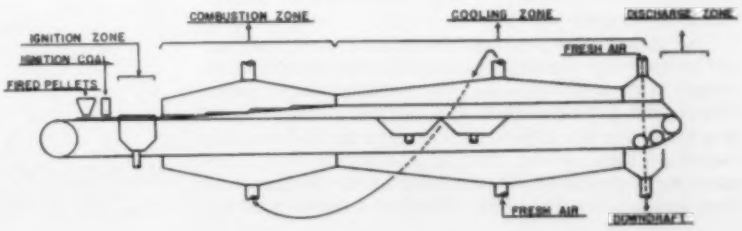
2) Many additives were tried in an effort to correct this deficiency. Limestone and bentonite were found to improve not only the aggregating properties, but also the ultimate fired strength. To be considered as a favorable grate-machine feed, a $\frac{3}{8}$-in. diam pellet should have a wet compression strength of 2.0 lb and be able to withstand five 8-in. drops before rupture; it should have a dry compression strength of 8 lb and be able to withstand 20 3-in. drops before rupture. The omission of 2.5 pct limestone from the green pellet mix reduces the fired strength of the pellets appreciably. Ban and Erck[2] have shown the effect of limestone on the fired strength of pellets produced from specular-hematite concentrate.

3) Laboratory studies revealed that $-\frac{1}{2}$-in., $+\frac{3}{8}$-in. diam pellets at a moisture content of 9.0 to 9.5 pct produced the most favorable grate feed. Larger pellets do not dry as rapidly as smaller pellets and do not agglomerate as thoroughly, resulting in a poorly fired product and low capacities. Smaller pellets fire satisfactorily, but the possibility of the bed fluidizing is increased considerably. A fluidized bed always results in an unburned product. Green pellets containing 10 to 11 pct water usually possess a considerable amount of surface moisture which causes the pellets to coalesce under static or vibrating conditions. Congealed pellet masses are very impervious to a gas stream and cannot be fired adequately. Green pellets containing less than 9.0 pct moisture are usually weak and break in either the final stages of balling, conveying to the furnace, or impacts from furnace feeding.

4) The quality of green pellet fuels has a direct bearing on the quality of the fired product. Fuels for firing green pellets rank as follows: coke, anthracite, low volatile bituminous, and high volatile bituminous. The disposition of fuel on the surface of pellets is required because the hot firing zone ascends so rapidly (over 1 in. per min) that the fuel must be readily accessible to the updraft air. Internal fuel usually reacted as a reductant rather than as a fuel. The necessity of using surface fuel limited the size of the fuel to either a size similar to that of the pellets, or to a finely powdered form. Powdered fuel was chosen because of the greater possibility of being more uniformly distributed throughout the pellet bed. Fuel:pellet ratios on the order of 4.0 to 4.5 pct of the green pellet weight are adequate for proper firing. Fuel quantities in excess of this amount increase the strength indices, but also increase the clinkering tendencies which are detrimental to the firing operation. Smaller amounts of fuels cause a weak, partially fired product to be produced.

5) An updraft flow rate of 100 to 120 cfm per sq ft of grate area produces the most favorable product recovery and highest unit capacity. Excessive amounts of air will either cause the pellet bed to fluidize or strip the heat from the pellets before they are thoroughly fired. Both conditions will result in a poorly fired product. Lesser amounts of air usually result in the loss of ignition or decrease the unit capacity tremendously.

6) Bed depths of wet pellets 8 in. or less produce the most favorable firing conditions. If bed depths



Simplified diagram of updraft, traveling-grate, pellet-hardening furnace at Eagle Mills, Mich. Plant is in full operation producing pellets for blast-furnace and open-hearth charging from — 325 mesh specular-hematite flotation concentrates produced at the Republic mine and mill.

exceed 8 in., bed pressures become high, pellets near the surface of the bed become excessively wet and coalesce, the updraft flow of air may become preferential, and the pellet bed may fluidize. The only disadvantage of smaller bed depths is the increased number of feeding stages required for the same depth bed.

On the premise that the pellets are to be applied in 8 in. layers, the time increment between feeding stages is critical for a fixed combustion rate. If a short time increment exists between feeding stages, moisture precipitation can cause the upper layers of pellets to coalesce and interfere with uniform gas flow. If a long increment of time exists between feeding stages, ignition between consecutive stages can be lost or the capacity will be decreased considerably. An increment of 5.8 min between additions of 8 in. layers produced the most favorable product in recovery and capacity.

7) Ignition is established by placing a 4 in. layer of −½-in., +3 mesh indurated pellets on the grate, covering these pellets with a monolayer of the same size anthracite coal, and subjecting this layer to the flame of a gaseous fuel under gentle downdraft conditions. Closely sized pellets are required in the hearth layer to produce a porous bed and insure an even distribution of heat. External gaseous fuel at 15,000 BTU per sq ft of grate area is required to successfully fire hematite pellets containing 9.0 to 9.5 pct water and 4.0 pct powdered fuel. The length of the ignition period is dependent solely upon the amount of BTU available to the hearth layer per unit of time. Laboratory data revealed that at the completion of the ignition cycle the surface pellets attained a temperature of 2200°F, pellets 2 in. lower reached 380°F, while pellets 4 in. lower were only 150°F.

Plant-Scale Operation

The results of the laboratory studies became reality in September, 1956, when the operation of the 2000 tpd pelletizing plant was started by the Marquette Iron Mining Co. at Eagle Mills, Mich.

Flotation concentrates produced at the Republic flotation plant are transported to the pelletizing plant by rail. As received, these concentrates contain about 6 pct moisture, and on an average they contain less than 50 pct −325 mesh material. Both the moisture content and the size consist are inadequate for good balling characteristics. To correct these deficiencies, the concentrates are metered out of the storage silos and transported by conveyor belt to the grinding section, which consists of two ball mills operating in open circuits. The ball mill pulp is pumped to disc filters which produce a filter cake containing 9.0 to 9.5 pct moisture.

The filter cake of proper size consistency and moisture is combined with predetermined quantities of bentonite and limestone to prepare the concentrate as balling-disc feed. This mixture of concentrate and additives is given a thorough fluffing and mixing in a PeKay mixer before being placed in the day bin, feeding the disc.

The thoroughly prepared fine material is metered out of the day bin at a controlled rate onto a conveyor belt. Although the concentrates have been thoroughly fluffed prior to the day bin storage, there is a tendency for these concentrates to re-compact, thereby affecting the balling characteristics. It is necessary, therefore, to recondition these fines before feeding the disc, and, a PeKay aerator was installed on the belt transporting the prepared concentrates from the day bin to the disc.

The fluffed and aerated fines are fed to the balling disc, where the fines are rolled in snowball fashion to the desired size green ball. Up to this point additions of coal have been purposely omitted from the process to avoid internal carbon content. As previously explained, it is quite necessary that the coal be added externally. To accomplish this, pulverized coal is added in metered quantities to the last stage of the disc operation. A fine spray of water is used at this point to assure adherence of the fine coal to the green ball.

Four discs are used to form the green balls coated with coal, and the product from each disc is fed to a different point on the traveling grate. The first disc product is fed directly on the hearth layer, immediately after the ignition section of the grate, at which point the updraft is started. The heat that has soaked into the indurated pellets during the ignition is then stripped from the hearth layer and ignites the coal in the first 8-in. layer of green balls.

This causes an induration zone to rise in the green pellet bed, and as this zone approaches the top of the first layer of green balls, the product from the second disc is placed on the bed. The induration zone continues passing through the first layer and starts igniting the second 8-in. layer of green balls. In similar manner the product from the third and fourth discs are fed to the grate machine until 32 in. of active green balls have been deposited.

Once induration has been completed, the volume of air is increased to complete the firing and at the same time extract the sensible heat from the top layer of fired pellets. These exhaust gases do not contain an appreciable amount of moisture and are used as the air source in the firing phase of the process.

The last section of the grate is used for downdraft cooling. Laboratory tests revealed that during the final phase of the updraft process there is a tendency for the top layers to remain hot. Adequate cooling of this layer of hot pellets is virtually impossible, but it has been found that by reversing the flow of air, the heat can be extracted from this layer and distributed through the mass, thereby reducing the hazard of discharging excessively hot material from the grate.

The machine discharge is screened for the purpose of eliminating fines from the shipping product. The fines are reground to obtain a size-consist similar to the original flotation concentrates.

Observations on Initial Plant Operation

Troubles of every manner and variety have been encountered during the initial start-up of this plant, which was developed directly from laboratory scale tests. However, experience to date indicates that all the difficulties encountered are mechanical rather than process. We are confident of the success of this system in producing a pellet to meet all of the strict specifications, established in initial research studies for a satisfactory pellet for blast furnace or open hearth charge ore use.

References

[1] R. L. Cleveland: *Sintering Practice at Ford Motor Company*, Blast Furnace, AIME Coke Oven & Raw Materials Proceedings, 1955, vol. 14, pp. 15 to 23.

[2] T. E. Ban and L. J. Erck: *Laboratory Procedures for Determining the Pelletizing Characteristics of Iron Ore Concentrates*, *AIME Trans.*, August, 1953, vol. 196, pp. 803 to 811.

Hardening Taconite Pellets

by Alan English and M. F. Morgan

EXPERIMENTAL work on the concentration and agglomeration of low-grade iron ores was started many years ago at the Mines Experiment Station of the University of Minnesota by E. W. Davis and his staff. From these laboratory results and the work of O. G. Lellep, consultant for the Allis-Chalmers Manufacturing Co., there were indications that the use of a downdraft continuous-grate furnace, patterned from a conventional-type sintering machine, would be practical. Consequently, a pilot plant was designed and constructed by the joint efforts of Allis-Chalmers Manufacturing Co. and Arthur G. McKee & Co. at Carrollville, Wis. Several years of work resulted in plans to build a large-scale pilot plant for commercial application. Such a pilot plant, built at Babbitt, Minn., by the Reserve Mining Co., was designed to produce 1000 tpd.

Sufficient metallurgical and operating data were accumulated to permit the successful application to the design of a commercial plant of any desired capacity. Based upon this data, a pelletizing plant having a 3¾ million ton per year capacity was erected by the Reserve Mining Co. at Silver Bay, Minn. and started operation in October, 1955. Provisions were made in the design to permit future expansion to a capacity of 10 million tons per year.

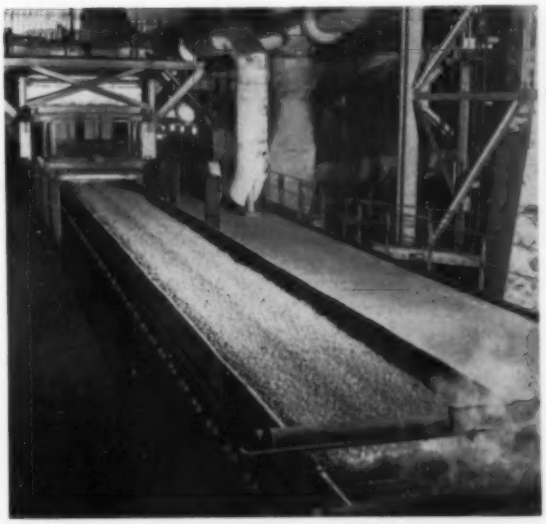
Raw Materials for Furnace

Raw materials used in both the experimental and the commercial plants were similar and consisted of magnetic taconite concentrates, anthracite fines, bentonite, and fuel oil. The magnetic concentrates, crushed to −150 mesh, contained 75 to 85 pct −325 mesh, and an analysis showed 64.5 pct total Fe, 9.0 pct SiO_2, 0.53 pct CaO, 0.67 pct MgO, 0.55 pct Al_2O_3, and 0.22 pct Mn.

Anthracite coal fines were used in all test work, but there is no reason why coke breeze or other forms of carbon could not be used. In the experimental stages −100 mesh and −200 mesh sizes were used, but the benefits from better distribution, expected of the finer sizes, were never realized. At the present time, no commercial plants are using coal ground finer than 28 mesh. The analysis of the anthracite coal, on a dry basis, was approximately 81.0 pct fixed carbon, 7.0 pct volatile matter, and 12.0 pct ash, with a rated heat value of approximately 13,000 BTU per lb.

Bentonite has been used as an additive almost since the inception of the pelletizing process. The liquid fuel must supply the thermal needs required by the process. No. 6 fuel is used in commercial plants, and both have an approximate heat value of 150 BTU per gal.

Based on a paper by ALAN ENGLISH and M. F. MORGAN who are with Arthur G. McKee & Co., Cleveland, Ohio.



Pelletizing furnace bakes pellets at 2400°F. Pellets lie on grate about 1-ft deep and are cooled gradually before being quenched in water.

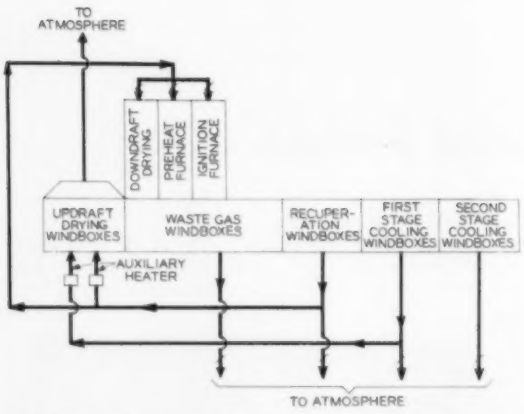
Balling drums were used initially in downdraft pelletizing for the production of green balls and have continued to be used as the process was developed, simply because they always have given satisfactory results. The objective of the balling drum is to produce green balls of the desired size, having sufficient strength to withstand handling with a minimum amount of degradation.

Recent balling tests, using magnetic concentrates containing 8.9 pct H_2O, showed an average wet strength of 1.17 lb and a dry strength of 0.72 lb when no additive was used, but when 0.5 pct bentonite was added, the wet strength increased to 1.30 lb, and the dry strength increased to 4.79 lb.

Commercial Furnaces

The main principle of pelletizing with the downdraft continuous-grate furnace, which embodies some of the features of a sintering machine, is the recovery and use of most of the sensible heat for drying and burning the product.

In the case of the commercial downdraft continuous-grate furnace, the coal-coated balls, produced in the balling section of the plant, are fed onto the grate by a vibrating-screen feeder. This feeding arrangement is of vital importance to the process to maintain a clean, level bed and to obtain good airflow and good permeability during the various phases of the operation. Bed height has also been given considerable attention, as maximum bed thickness will obviously give lower ignition fuel

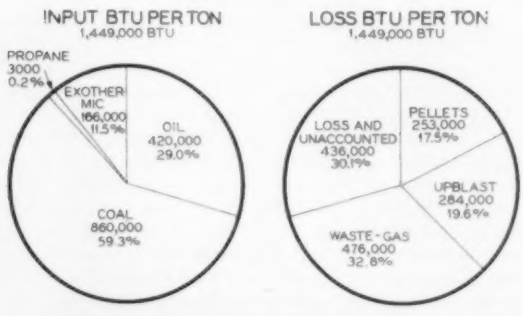


Air flow diagram for the commercial, downdraft, continuous-grate furnace. Grates are 6 ft wide and have 28 windboxes divided into five sections: updraft drying, waste gas, recuperation, first-stage cooling, and second-stage cooling.

rates and promote maximum recuperation of hot air within the bed. However, bed height is a function of grate speed for a given production. In actual operation a bed height between 10 and 12 in. appears to give the best results. The balls are subjected to the same treatment on the grates in the commercial operation as outlined for the experimental downdraft grate furnace, except that greater attention was given to updraft drying and cooling. The grates are 6 ft wide and 168 ft long and have 28 windboxes divided into five sections or zones, designated as the updraft drying, waste gas, recuperation, first-stage cooling, and second-stage cooling. The windbox allocation for these zones is as follows: numbers 1 to 7, updraft drying; 8 to 11, downdraft and preheat drying (waste gas); 12 and 13, ignition (waste gas); 14 to 22, burning and recuperation; 23 and 25 first-stage cooling; and 26 to 28, second-stage cooling. Windboxes 8 to 28 are on downdraft.

Updraft drying is accomplished by utilizing 900°F air from the recuperation zone and the first-stage cooling zone of the furnace. This drying is accomplished in 25 pct of the total length of the grate.

Downdraft drying, preheating, and ignition utilize recuperated 900°F air in a large ignition furnace which is divided into three sections. The recovered air is raised to the required temperatures by burning No. 6 fuel oil. Temperatures of about 1400°F for drying, about 2000°F for preheating, and 2350°F for final ignition are used. These steps



Heat balance on commercial, downdraft, continuous-grate furnace; input at left and consumption at right.

of the process are accomplished in approximately 21.5 pct of the total grate length. The remaining 53.5 pct of the grate is used for burning and cooling purposes.

Burning and cooling of the balls is accomplished by pulling large volumes of air through the bed of pellets. The actual temperatures in the recuperating windboxes are about 1250°F, but, because of the type of fans used in the process, tempering must be carried out to reduce this temperature to 900°F.

Temperatures of approximately 900°F are also obtained from the first-stage cooling section, and this is all used for updraft drying purposes in the first three windboxes, the remainder of the updraft drying air being obtained from the recuperation section. Air temperatures of approximately 700°F are obtained from the second-stage cooling section, but this air is not used at the present time.

Pellets that have been subjected to this particular treatment and discharged at temperatures of approximately 600° to 700°F are water cooled and screened before being stockpiled or loaded into lake carriers.

A practical heat balance for the production of 2400 tpd on a downdraft traveling-grate furnace is shown in the table below.

Operating Results

The last of the six downdraft continuous-grate furnaces at Silver Bay, Minn., was placed in operation more than one year ago. Since that time, excellent progress in production rates has been made. The plant was designed for a total production of 12,000 long tons of pellets per day, but it is now averaging between 15,000 and 16,000 tons per day.

The pellets produced analyze about 63.0 pct Fe and 9.7 pct SiO_2. The quality of the product is determined by the standard ASTM tumbler test and is considered good, averaging about 12 pct of the −28 mesh fraction. This tumbler test consists of revolving a 50-lb sample in a tumbler drum at the rate of 25 rpm and screening at 28 mesh.

Engineering Features of the Commercial Plant

In designing the plant, it was specified that a few hours supply of concentrate for pelletizing should be available in the event that the concentrator should be shut down for some reason, and if the pelletizing plant was down, then sufficient bin capacity should be available to keep the concentrator operating for a few hours. This was accomplished by installing large storage bins, each bin serving a closed balling drum circuit by means of a table feeder. There are three balling drum circuits, in-

Table I. Typical Heat Balance for Downdraft Continuous-Grate Furnace Producing 2400 tpd

	BTU per Ton Pellets	Pct Total Input or Consumption
BTU Input		
Fuel oil	420,000	29.0
Propane gas	3,000	0.2
Anthracite coal	860,000	59.3
Exothermic reactions	166,000	11.5
Total	1,449,000	100.0
BTU Consumption		
Pellets	253,000	17.5
Updraft hood exhaust	284,000	19.6
Waste gas fan exhaust	476,000	32.8
Loss and unaccounted	436,000	30.1
Total	1,449,000	100.0

cluding coal coating drums, operating with each grate furnace to produce a ball approximately of ⅜-in. size.

Control equipment proportions the bentonite into the concentrate, and the coal onto the surface of the green balls. The same type of control equipment is used for regulating the feed to the furnace.

As stated earlier, feeding the grate-furnace is accomplished by means of a vibrating screen. The fines of balled concentrates are screened out, and the feed is evenly distributed across the 6-ft width of the grate. Feeding the grate was quite a problem during the development stages and was solved only by the ingenuity of the operators in collaboration with the screen manufacturers.

The design of the grate furnaces and the ductwork to take care of the heat problems, that were apparent when handling large volumes of hot air at different temperatures, was quite an engineering feat. The ductwork was designed to take care of expansion in all directions. The fans were designed to handle 900°F air.

The product handling arrangement is such that the product from the machine passes over a grizzly screen set at 4 in. The oversize is crushed to 4 in. by means of a single roll crusher. The −4-in. product is wet screened over a single deck, two section, vibrating screen at 3/16 in. and 1½ in. The −3/16-in. fines are wet classified at 28 mesh with the −28 mesh size returning to a fines recovery system and the +28 mesh size passing as product. Clinkers of pellets larger than 1½ in. are water quenched in a drum before joining the remainder of the product to be conveyed to the stockpile or to product handling facilities for loading into lake carriers.

The fines recovery system consists of a central pumping station, which handles the return fines from all grate furnaces, a hydroseparator, a thickener, and a filter.

General Comments

There are a number of phases of this operation that are considered most important for a successful downdraft continuous-grate furnace operation and must be emphasized. At all times good balls must be produced; the balls must be distributed evenly across the grate furnace at the desired bed height; correct proportioning of bentonite to the concentrate and coal to the formed balls is essential; and regulation of temperatures and airflows to maintain continuity of operation is of primary importance.

The Traveling Grate—Updraft/Downdraft

The Lurgi Combined Technique

by Kurt J. E. Meyer and Hans Rausch

A PELLETIZING plant in Germany must be able to process ores of different origins, having quite different characteristics. This requirement was of great importance for the development of the Lurgi process. For the production of green pellets a machine would, therefore, have to be capable of dealing with all kinds of raw materials, and hardening must be done in a furnace, the temperature of which is adjustable to the different temperatures of the ores.

Making Green Pellets

To produce green pellets, experiments were made on a number of machines, such as drums, vacuum extrusion presses, and compacting machines. In 1949, Lurgi was the first to use pelletizing discs to produce iron ore pellets; until then this type of machine had been used exclusively in the cement industry.

Balling machines working under pressure cannot be used without limitations, and the extrusion press is suitable only for sufficiently plastic ores or for mixtures with plasticizing additions. In other respects, too, the extrusion press shows remarkable differences compared with the pelletizing disc and the drum, especially with regard to the strength, bivalent iron content, and the uniformity of the pellets.

Although having a number of advantages, particularly concerning high capacity, the pelletizing drum has one decisive drawback; it does not discharge green pellets of even approximately the same diameter, therefore, each drum has to be followed by a screen to separate the undersize.

In comparison with the drum, the pelletizing disc offers some noteworthy advantages, such as its light weight, a greater possibility of varying the depth, the angle of inclination, and the speed of rotation. Moreover, the disc discharges green pellets of almost equal diameters which makes screening unnecessary. The latter fact and the use of a special conveying system for the handling of the green pellets make the addition of binding agents unnecessary.

Industrial-Sized Plants

Pelletizing discs: For large capacities, a pelletizing disc with 16-ft diam is used. It is able to produce about 18 to 20 tons per hr of green pellets of 1 to 1¼ in. diam. If balls of smaller diameter are produced, the capacity is higher. The speed of rotation is about 4½ rpm, with an angle of inclination of about 48°. No auxiliary equipment is needed, except suitably attached scrapers to prevent the building up of deposits on the floor and the side walls. Water, as far as necessary, is sprayed on through nozzles arranged over the disc. No binders are added. Arrangements have been made for a gentle handling of the balls, which are wet and sensitive to drops. As the disc produces balls of almost uniform diameter, eliminating the undersized material by screening is not necessary.

A special green-pellet handling system is used at the charging point of the machine in order to separate broken balls or fragments thereof from the feed.

Abstracted from an article by KURT J. E. MEYER and HANS RAUSCH who are with the Lurgi Gesellschaft für Chemie und Huttensesen mbH, Frankfurt am Main, Germany.

It consists of an inclined conveyor belt running upwards, the inclination and the speed of which can be varied. The speed of the balls rolling down this inclined belt is slowed by rubber baffles, and all irregularly-shaped pieces, as well as fines, are carried up and discharged over the head pully. Furthermore, this system increases the mechanical strength of the balls considerably by its rolling action. It is also an excellent method of feeding the balls onto the machine evenly distributed across the width of the pallets.

Pellet-hardening furnace: In a pelletizing plant, the sintering machine itself is subjected to quite different conditions than in the ordinary sintering operation and must be equipped accordingly. A particular requirement is to protect the side walls and pellets against excessive heat. In charging, therefore, a grate layer of hardened balls and fragments, $-\frac{5}{8}$ in., is fed onto the grates. This also serves as a regenerator to preheat the cooling air up to a certain degree when moving into the updraft zone. The side walls are covered with finer particles recirculated from the discharge of the machine and charged on to the pellets from a storage bin.

Besides offering an excellent protection against heat for the metallic side-wall plates of the machine, the side-wall layer also has another advantage; the pellets along the sides of the bed are heated more uniformly and, therefore, correspond in quality with those in the center of the bed. By careful screening of the side-wall layer it is also possible to avoid the marginal effect on the gas flow which would otherwise conduct most of the hot gases down along the side wall plates, due to the smaller resistance toward the flow in this region.

The drying of the pellets is done under suction, with heated cooling air coming from the end of the machine and circulated gas from the windboxes serving as drying media. After drying, the pellets are steadily heated until they reach the necessary hardening temperature. This temperature is held for several minutes, so that there is sufficient time for crystalline transformations to take place. This too, is done under downdraft with the gases recirculated and leaving the system through the drying zone as waste gases.

In the cooling zone, cold air is blown into the wind boxes and passes through the bed, cooling pellets, hearth layer, and hot pellets, thereby becoming heated itself. The hot air is drawn from the surface of the cooling zone and fed into the gas circulation system. At the discharge end a screening station separates the material into finished product, grate layer, and side-wall layer.

Special Features of the Process

The process developed by Lurgi, using gas or oil heating only, differs in the following characteristics from other processes:

a) The addition of binders for improving the quality of the green pellets and the addition of materials for increasing the ultimate strength is not necessary.

b) By using gas or oil exclusively as fuels not incorporated in the pellets, it is possible to regulate the burning process on the sintering machine accurately and to produce and maintain the temperature required in each case.

c) The use of the sintering machine as a burning apparatus permits the regulation of the vacuum in individual windboxes and thereby the control of the gas flow through the charge in each separate stage and consequently also a very close control of the reaction.

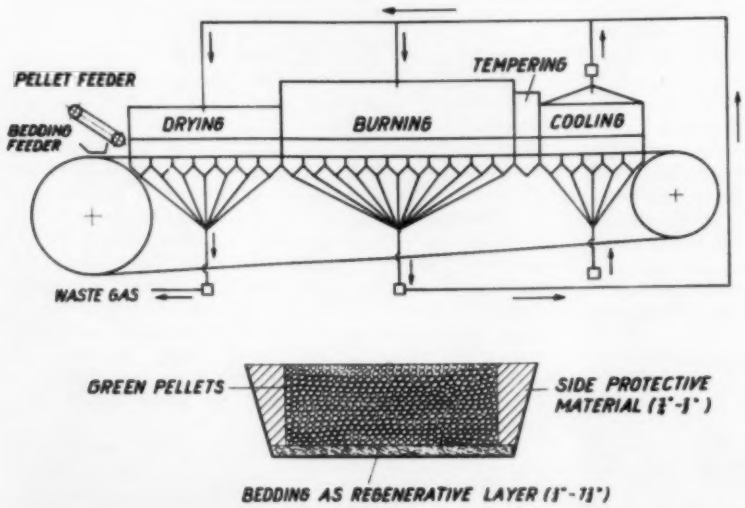
d) By closing the valves on one or two windboxes after the pellets have been heated to the final temperature, the flow of gas through these can be stopped completely, which improves the strength.

e) The pellets are cooled by updraft through the last windboxes, which is advantageous, not only from a mechanical, but also from a process point of view. Thus, the air first cools the grates and the grate layer and reaches the hot pellets in the first stage of cooling in a preheated state, which is of importance for the final strength of the balls.

f) The exclusive use of gas or oil for heating makes it possible to produce suitable and different gas atmospheres, whether oxidizing, neutral, or reducing, at definite points of the machine.

g) The process makes it possible to pelletize magnetite, hematite, limonite, or mixtures of these.

The first pelletizing plant using the Lurgi process was built for the International Nickel Co. of Canada at Coppercliff, Ontario, Canada, for production of about 1200 tpd. In the US, the Dravo Corp. of Pittsburgh has been licensed to construct this equipment.



Schematic layout of a Lurgi pelletizing machine with pallet feed. Special features of the process are that (1) addition of binders is not necessary and (2) gas or oil are used exclusively as fuels not incorporated in the pellets. The latter permits greater control of temperature and oxidizing conditions on sintering machine. Magnetite, hematite, limonite, or mixtures of these may be pelletized by this process.

Pelletizing Taconite Concentrates

Another line of development for the agglomeration of ores and concentrates is the shaft furnace. For very fine ores, this process offers advantages in fuel economy and low capital installation cost, while continuing to produce a high quality blast furnace material.

by F. D. DeVaney

IT is of great interest that the various organizations engaged in the search for a cheap and efficient agglomeration process for fine magnetite concentrates—essential if the taconites are to be utilized—have ended up with processes that are basically different. This paper describes the development and the present status of the shaft-type furnace as now utilized by the Erie Mining Co., which is managed by Pickands Mather & Co.

The shaft furnace has always had an appeal to metallurgists because of the simplicity of the design and the possible low fuel consumption. Work done on pelletizing at the University of Minnesota Mines Experiment Station by E. W. Davis and his associates determined that it was possible to roll up fine magnetite concentrates in a balling drum, and that, if such balls were fired at a sufficiently high temperature, a hard, indurated pellet, well adapted for use in a blast furnace, could be made. Early furnaces had no heat recuperation and the heat consumption was in the order of 2 million BTU's per long ton.

Early Attempts with Pebble Stove Furnaces

Erie initially attempted to secure high heat recuperation by the use of two, parallel, pebble-stove-type furnaces in which the stoves were blown alternately. This design had excellent heat economy but proved unworkable in practice. The next development was the placing of one pebble stove directly above the other with a relatively narrow neck between. Cold air was blown up the bottom of the lower stove and most of this preheated air was bypassed into a combustion chamber where the temperature was raised to approximately 1800°F. This hot gas was then brought into the upper stove, where the actual induration of the pellets occurred.

Under laboratory conditions, this furnace, which was of 30-in. diam, performed well and gave an excellent product with a heat consumption in the order of 300,000 BTU per ton. A commercial size 12-ft diam furnace was then built along the same general lines, with a rated production of 600 tpd. This capacity was never achieved and numerous difficulties developed in feeding the pellets, in the flow of material through the restricted area between the two stoves, and in discharging fused chunks. It was also very apparent that problems of material flow and gas distribution were much more serious in a large diameter shaft than in a small one.

The Rectangular Furnace

The next development was the construction of a rectangular furnace in the place of the round furnace. This incorporated other changes in design that led to the development of a successful process, mainly the installation of an improved feeder, the removal of all constrictions in the shaft, and the installation of chunk breakers for breaking up the occasional cluster or chunk that might be formed.

In the development of the rectangular furnace, the Lebanon Div. of Bethlehem Steel Co. worked closely with Erie. Ideas were freely exchanged and furnaces were built both at Aurora, Minn., and at Lebanon, Penn., for pelletizing fine magnetite.

Preparation of Balls

The preparation of balls suitable for feed to the shaft of a furnace presented many problems. The balls formed must have sufficient cohesiveness and strength so that they can be handled over the necessary conveyors and furnace feeders and deposited intact on the feed line of the furnace. In order to produce good balls, it is necessary to control the

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moisture of the feed to the balling drum and maintain a proper condition of the rolling surface. Such a drum was ultimately developed by the invention of a reciprocating cutter bar, which controls the thickness of the cake on the inside surface of the balling drum but yet gives a surface which is relatively rough and not glazed or smooth; thus, the balls being formed will roll rather than slide. It is essential that the balls be formed slowly so that they have a high density; it is also essential that the balls be rather closely sized and that no fines be permitted to enter the furnace. In the balling drum, as developed by Erie, this is secured by placing a trommel at the end of the drum with openings that are approximately ⅝ in. All balls that are finer than this size are conveyed back to the feed end of the drum where they join the new feed to the drum. Bentonite, added in amounts of 10 to 15 lb per long ton, markedly increases the strength of the balls in the dry state, and to a somewhat lesser extent, in the fired state.

Furnace Operation

The furnace now in use at the Erie plant consists of a rectangular shaft 6 ft wide x 14 ft long and approximately 45 ft high. The shaft is full at all times with pellets and an amount is drawn off from the bottom at the same rate the green balls are fed into the top, so as to keep the feed line uniform. The amount of pellets in the furnace is about 180 long tons, and these move continuously down the shaft at a rate of ½ to 1 in. per min, depending on the feed rate. The pellets from the balling drum are charged onto the feed line of the furnace by a special feeder which travels in a rectangular path.

The furnace operates on a counter-flow principle. As pellets descend, they are heated in the upper shaft by gases from the combustion chamber and by preheated air coming up the shaft. The indurated pellets below the ports are cooled by an uprising current of air blown into the furnace at the level of the chunk breakers; this tends to abstract the heat from the descending pellets. Approximately 35 pct of the total air is admitted to the two combustion chambers, one on each side of the furnace. In these combustion chambers, the incoming air is heated to a temperature of approximately 2350°F. This hot air enters the shaft proper through a series of ports and rises up the upper portion of the furnace, where the pellets reach temperatures above 2400°F. Pellet temperatures in excess of the combustion chamber temperatures are reached because the mineral being indurated is magnetite, and since the atmosphere in the furnace is strongly oxidizing, the magnetite is almost entirely converted over to hematite with the liberation of approximately 207 BTU per lb of iron in the pellets. This furnace operation is unique in that, with the exception of the upper few inches at the top of the furnace, the pellets are always at a higher temperature than the ascending gases. The surfaces of the pellets are cooler than their interiors, which creates partial fusion conditions in the interior but not at the surface. This is important, as it lessens any tendency of the pellets to stick together and insures satisfactory material flow.

The hot gases rising up through the shaft encounter the charge of green unfired balls which are being deposited continuously, and these green balls abstract the heat from these gases, giving a top gas temperature which is normally in the order of 300°F. The heat line in the furnace can be nicely balanced by adjusting the rate of blow to the amount of feed.

The heat gradient in the upper part of the furnace is very sharp; the incoming green balls are at atmospheric temperature, and within a distance of 10 in. they reach a temperature near 2400°F. The balls remain at this temperature in the furnace until they have reached the level of the ports carrying in the air from the combustion chambers. Below these ports the pellets are progressively cooled by the upcoming air admitted at the chunk breaker level and are discharged at the bottom relatively cool. The temperature of discharge varies with the rate at which the furnace is being operated, and, to a certain extent, on the amount of cooling air being blown.

Chunk Breakers

Chunk breakers are installed at two levels in the furnace. These consist of water-cooled shafts on which are mounted tooth-like projections which break up any descending clusters. The upper set has three shafts in which the rows of teeth are spaced 14 in. apart. Their main purpose is to break

Operating Statistics for Experimental Shaft Furnace, September 1956*

Pellets	
Pellet production, tons	30,637
Fe in feed, pct	64.09
Fe in pellets, pct	63.12
Quality, tumble test No.	85.3
BTU consumption, per ton of pellets in cars	753,680

Operating Data	
Pellets, tons per operating hr	47.14
Total air pressure, psi	6.0
Air volume, std cfm	22,300
Furnace recovery, pct	102.21
Furnace yield, pct	88.04

Temperatures, °F	
Avg top gas exit temp	238
Bottom discharge temp	506
Combustion chamber temp	2350

Additives, lb per ton	Pellets	Feed
Coal	15.7	14.0
Bentonite	15.4	13.7
Soda ash	1.6	1.5
Fuel oil, gal per ton	4.3	3.8

Air to pellet ratio	1:1
Air to combustion chamber, pct	37
Total availability, pct	90.27
Avg product, tons per sq ft per day	12.16
Max product per calendar day, tons	1212

* **Definitions**

Tonnages: Dry, long tons

$$\text{Total availability} = \frac{\text{Hr actually operated}}{\text{Total hr in period}}$$

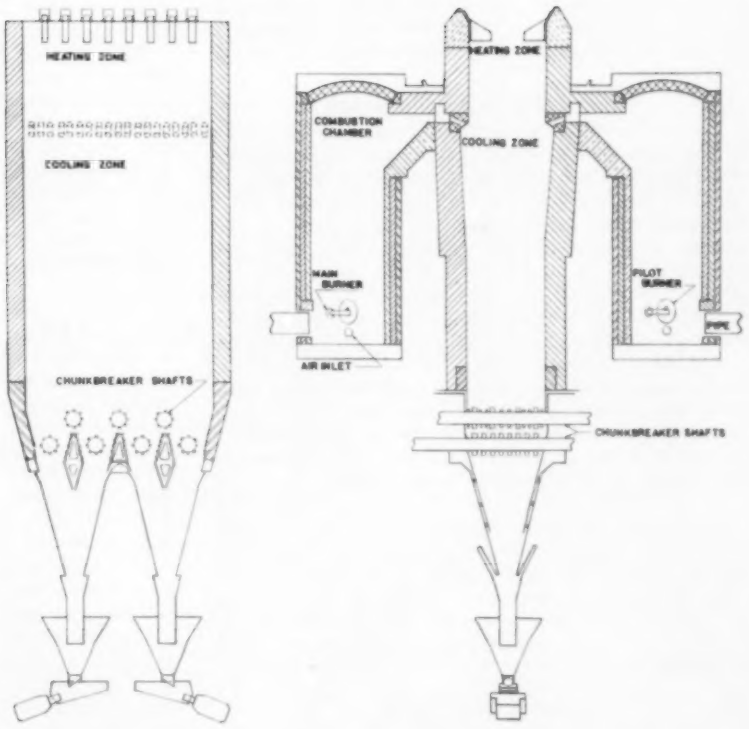
$$\text{Furnace recovery} = \frac{\text{Total tons discharged from furnace}}{\text{Total dry tons material charged to furnace}}$$

$$\text{Furnace yield} = \frac{\text{Total tons pellets shipped}}{\text{Total dry tons material charged to furnace}}$$

$$\text{Avg production per sq ft per day} = \frac{\text{Tons pellets in cars}}{\text{No. of days operated x cross sect. area of furnace (84 sq ft)}}$$

Furnace Design

Shaft furnace for pellet hardening at Erie Mining Co.'s plant in northern Minnesota. The furnace consists of a rectangular shaft 6 ft wide x 14 ft long and approximately 45 ft high. Chunk breakers are installed at two levels in the furnace to break the occasional chunk that is formed and to regulate the flow of material down the shaft. The plant—managed by Pickands Mather & Co. and designed for 24 shaft furnaces—is nearing completion with 12 already in operation.



up any large chunks that may inadvertently be formed. The lower set of chunk breakers consists of four similar shafts, but on which rows of teeth are placed 5 in. apart, at which size the fired material can readily be discharged through the restricted furnace discharge legs.

The discharge openings are free to the air and a calculated loss of air through these openings is taken, which amounts to between 3 and 5 pct of the total air blown. The loss of air is held to this amount by restricting the diameter of the discharge pipes. By such a design it is possible to eliminate the need for mechanical devices for minimizing the loss of air. The cooling air is admitted to the furnace through the louvre-like devices, having long, slot-like openings. This air effectively cools the chunk breakers, and, of course, the descending pellets.

One of the main functions of the chunk breakers, in addition to breaking the occasional chunk that is formed, is to regulate the flow of material down the shaft. We have found that, with normal operation, the amount of material that requires breaking in the furnace will not exceed 5 pct, but the chunk breakers give a more uniform descent of material. As a direct result of this, a more uniform flow of air up through the shaft is achieved, and thus the over-all performance is materially improved.

Divider Plates Assist Heating

Near the feed line of the furnace there are a number of divider plates on each side of the furnace. These divider plates are spaced about 18 in. apart; there are eight of them on each side of the furnace. They are made of a chrome-nickel casting, and their purpose is to divide the down-coming, and as yet, still unfired pellets, into zones. The passage of air is always greatest near a wall, and such dividing plates furnish additional wall area. Their presence assists in securing more uniform heating of the green balls and the prevention of masses of consolidated material which have lost most of their pellet structure.

Heat is supplied to the combustion chambers by the burning of oil. This oil may be either a light fuel oil or a heavy residual oil such as Bunker C. If high-grade magnetite concentrates are used, or if the furnace is operated at a moderate rate, no other fuel is required. If the furnace is operated at maximum capacity, 10 lb per long ton of coal is mixed with the concentrate. At high capacity rates, this small amount of fuel tends to insure kindling of the magnetite in the pellets, giving a more uniform heat distribution over the upper part of the furnace charge.

The amount of air required is very close to the theoretical amount necessary for heat interchange, taking into consideration the weight of the pellets and their specific heat, and the weight of the air blown and its specific heat.

Refractory Problems are Minimal

Brick work in this type of a furnace presents no great problem, since the temperatures never reach an excessively high point. The main portion of the shaft is lined with a good quality fire brick, and the lower portion of the main shaft is lined with a hard brick to withstand the abrasion of the pellets which become harder as they are cooled. Insulating brick was used at one time in the shaft proper next to the shell, but this construction has been abandoned due to the tendency for gases to abrade holes in this softer brick. In the combustion chamber, where there is no differential in pressure, insulating brick is used between the shell and the

fire brick interlining. Life of the fire-brick lining is not known, but it is evident that several years of life can be expected before a relining job is necessary.

Green Pellet Feeding Important

Correct feeding of the pellets onto the stockline of the furnace is of great importance. Balls must be deposited evenly over the surface of the bed to secure a definite pattern, and this cycle must be so regulated that green balls are deposited on the charge at about the time that the heat line has advanced to one or two-ball depths below the top of the furnace. This is accomplished by having the feeder traverse a rectangular path and spread the balls out by means of a flipper at the end of the conveyor. The feeder is so designed that exactly the same number of balls will be laid down in a definite time interval, whether the feed belt is advancing or retracting. The feeder is also designed so that if a low place occurs in the bed, the feeder, by means of a traveling feeler, slows down its rate of travel across this area and deposits a heavier load of balls. The feeder is also provided with a mechanism which measures the height of the charging line, and this in turn regulates the rate of discharge from the bottom of the furnace so that the feed line is always at a uniform level. The furnace is entirely automatic and requires little attention.

Losses Kept to 10 Pct

In the Erie pelletizing operation the furnace discharge is screened, and all material finer than −3/16 in. is reprocessed. The product shipped is usually sprinkled with water to allay any dust that may arise; 1 pct water in the pellets is sufficient to prevent the formation of dust. Undersized material is screened, and all material coarser than 14 mesh is reground. This reground material, together with the relatively small amounts of dust that are collected from the top dust collector and a dust collector handling the furnace discharge, are reprocessed. In practice, the total amount of dust formed is about 4 pct, and the amount of chips needing reprocessing is about 6 pct, making a total of approximately 10 pct that must be reworked. One of the inherent advantages of the shaft pelletizing process is the production of a sized product containing no fines, with the necessity of reprocessing a relatively small amount of undersized material.

Operating Statistics

Data given in the table represent production from a single furnace for the month of September 1956.

The low BTU consumption compared with other forms of induration is secured by the high degree of heat recuperation. As the table indicates, the average top gas temperature is only 238°F, and the bottom discharge temperature, even at this high production rate, is 508°F. These temperatures, compared to the temperature at the indurating zone, 2450°F, indicate the degree of recuperation. There is a decrease in the iron content of the pellets as compared to that of the feed; this comes about largely because of the oxidation of magnetite to hematite, and it is also shown by the furnace recovery of 102.21 pct. The furnace yield figure shows that during this particular month almost 12 pct of the furnace feed reported as chips or as dust and was reprocessed. During this entire month, there were no delays for major repairs nor for metallurgical reasons. The total delay time was due to scheduled repairs and minor mechanical delays.

Erie Mining Co.'s large new plant at Aurora, Minn., is nearing completion and the pelletizing plant consists of 24 shaft furnaces. As of Jan. 1, 1958, twelve of these furnaces had been completed and were in successful operation. Together, the 24 furnaces will have a combined capacity of at least 7½ million tons of pellets per year or about 21,000 tpd. These furnaces will be operated in units of four with a crew of three men to look after the balling and pelletizing operation for each four-furnace unit.

Operating Costs

Some comments are probably in order relative to operating costs. The fuel consumption of this process as compared with other methods of agglomeration is unquestionably lower. As far as additives are concerned, these are in the same order as those required in grate machines in which balls are pelletized. The total power consumption in a shaft furnace procedure, including all auxiliary operations, such as balling, induration, dust collection, and regrinding of chips, is in the order of 20 kw-hr per ton of pellets produced. This is of about the same order required in the grate sintering of balls, but it is somewhat higher than that required for sintering and nodulizing. At first thought, it might seem that the cost of operating labor for shaft furnaces might be higher than for other processes because of the capacity of each individual furnace. However, because of the relative simplicity of operation and the ability of operators to look after a number of furnaces, this operating labor charge is about the same as for other processes. Maintenance and repair labor on the shaft furnaces as now developed is believed to be lower than other agglomeration processes because of the relatively few moving parts in the shaft furnace. Such furnaces have only a mechanical feeder, slow-moving chunk breakers, and a relatively simple vibrating discharging device. There are no other moving parts.

Capital Costs

The initial cost of any agglomeration plant is not low. A figure in rather general use in the trade is that the cost of a modern sintering plant is in the order of $6.50 per ton of annual capacity. While the cost of constructing a shaft-type pelletizing plant will vary for different locations and for different types of material, it can be definitely stated that the comparable cost for a shaft pelletizing operation will be less than for sintering. Features of this process and its apparatus are covered by patents and patent applications, and arrangements have now been made to engineer and construct such pelletizing plants for industry.

In conclusion, it may be stated that the shaft furnace has definitely found a place in industry for the induration of fine magnetite concentrates, and it also appears to have interesting possibilities for other materials. Twenty-one of these furnaces are now in use in this and other countries, and there are under construction 14 additional furnaces which will be in operation in 1958. A number of other installations in various parts of the world are also presently being given serious consideration. The acceptance of this furnace has come about largely because of the quality of the product, the low fuel consumption possible, and economies in both the initial capital and operating costs.

Structural Control of Contact Metasomatic Deposits in the Peruvian Cordillera

by Alberto J. Terrones L.

THE classical papers on contact metasomatic deposits by Lindgren on the Clifton-Morenci district,[1] by Barrell on Marysville, Mont.,[2] and by Goldschmitt on the Oslo district, Norway,[3] laid the foundation for understanding of the importance of separating the metamorphic process from the subsequent metasomatic stage. Knopf[4] made a big step forward by recognizing that sulfide ore minerals are invariably younger than silicates and by further stressing the importance of structural control[5] in ore finding. Some years later Harrison Schmitt[6] fought the idea that contact metasomatic deposits are erratic, irregular, bunchy, economically marginal, and of small size, concluding that these descriptions have little factual basis. He emphasized the importance of detail mapping and careful geological study as fundamental requirements for a better understanding of these deposits.

This article presents a comparative description of the structural features at the Magistral, Antamina, Morococha, Vilca, Ferrobamba, Katanga (Quibio), Tintaya, and Huarca contact deposits (Fig. 1). Further, it will describe how these structural features controlled the emplacement of the intrusives, their shape, distribution of metamorphic and metasomatic halos, and sulfide deposition in post-skarn structural channelways. Finally, the modifications introduced by a superimposed hydrothermal stage recognized at some localities will be discussed.

Primary exploration and careful sampling of recognized structural targets were instrumental in outlining the copper ore potential at the Antamina and Tintaya districts, thus proving the benefits and reward of careful geological examinations in this type of deposit.

Fig. 1—Location map of Peruvian contact metasomatic deposits.

The Magistral District: This district lies in the Province of Pallasca, Department of Ancash, in northern Peru, at 8° 16′ S and 77° 47′ W. High to medium grade copper orebodies in garnetite, bordering a quartz monzonite stock, are exposed at the bottom of a glaciated valley in the western slope of the Andes at 4250 m (14,000 ft)* elevation.

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* Conversions of metric units to English units are approximate.

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A quartz monzonite stock, elliptical in plan (Fig. 2), cuts across the middle Cretaceous (Machay) limestone on the southwest flank of a northwest-trending (N 40°-45° W) anticline. A major southwest-dipping reverse fault, striking parallel to the folding, is exposed several hundred meters west from the center of the intrusion. Marble and porcellanite (pyroxene rock) are the products of the metamorphic stage. The writer noticed that the porcellanite layers selectively metamorphosed the more shaly members of the sedimentary sequence and extend much farther away from the intrusive contacts than does the marble.

Garnet replaces marble and pyroxene rock forming a metasomatic aureole 120 to more than 200 m (450 to 650 ft) wide around the stock and along branching dikes or sills. In general the garnetite is medium grained, but locally it is distinctly coarse, with individual crystals up to 2.0 to 2.5 cm (0.8 to 1.0 in.). The author observed that lenses of coarse grained garnet selectively replaced marble beds, whereas felsitic garnet appears to be more frequently associated with porcelainized (pyroxene rock) beds. This strongly suggests that during replacement the garnet preserved the original metamorphic texture of the rocks (formed during the metamorphic stage). This effect seems to be more pronounced in the outlying borders of the garnetite than close to the intrusive contacts.

Chalcopyrite and pyrrhotite are the most abundant sulfide minerals, with pyrite, molybdenite, sphalerite, and galena in subordinate amounts. Magnetite is locally abundant. In addition, D. H. McLaughlin[7] reports arsenopyrite, native arsenic, jamesonite, tethahedrite, and veinlets of supergene chalcocite. Most of the oxidized sulfide bodies were eroded by glacier action. Secondary enrichment is negligible.

Sulfide mineralization, essentially post-garnetite, forms either lenticular high grade copper ore concentrations along post-garnet fractures or medium to low grade disseminations controlled by minor fractures and the more pervious coarse garnetite layers. Ore mineralization is more restricted to zones at the border zones of garnet, either along the monzonite contact or following the outlying marble and porcellanite contacts. A few irregular occurrences are localized in the heart of the garnetite zone.

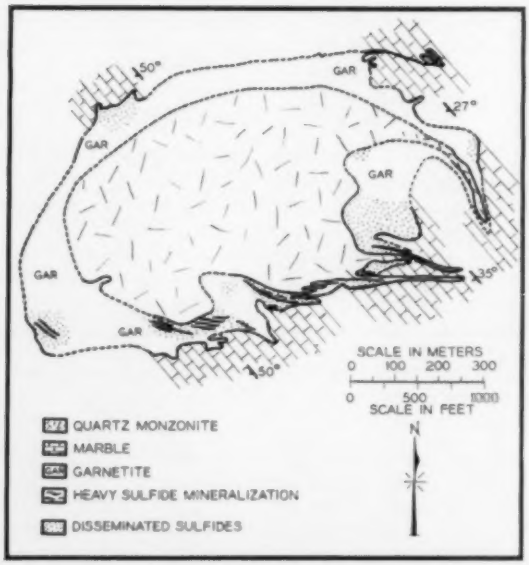

Fig. 2—Surface geology of the Magistral district, Peru. (After map by D. H. McLaughlin, modified from field notes by A. J. Terrones.)

The width of the high grade vein-like lenticular bodies varies from a fraction of a meter to 6.0 m (1 to 20 ft). Their strike length is 25 to 50 m (80 to 160 ft). The high grade lenses are not isolated; they are linked bodies surrounded by sulfide disseminations (Fig. 2) forming continuous zones of milling grade ore. Small sulfide bodies also occur along branching dikes and sills.

The writer observed that disseminated sulfides occur mainly as filling the interstices between coarser garnet crystals. After microscopic investigations McLaughlin reached the same conclusion,[7] stating that sulfides "occur as irregular grains in the garnetite moulded about and corroding silicates...." This proves that ore mineralization is definitely later than garnetite.

Moderate argillic alteration, exposed at some of the branching dikes, is the only evidence of hydrothermal activity. Except for local pyritization with sparse chalcopyrite, the quartz monzonite stock is practically fresh.

The Antamina District: The Antamina district is located in the Province of Huari, Department of Ancash, in the northern part of Peru, at 9° 32′ S and 77° 04′ W, with elevations ranging from 4200 to 4500 m.

An irregular quartz monzonite intrusive, in part concordant with bedding and in part cross-cutting as an irregular dike feeder, intruded a dome of middle Cretaceous limestone (Jumasha limestone according to Bodenlos and Ericksen).[8] Dikes and sills branch out from this irregular intrusion or occur as seemingly isolated bodies probably connected to a buried stock. The main quartz monzonite intrusive, covering an area of more than half a square kilometer, is exposed at the bottom and eastern side of a northeast-trending glacial valley. Andesite porphyry dikes, outcropping near the southeast corner of the district, very likely represent offsprings of a more basic differentiate (diorite) at depth.

The northwest portion of the Antamina dome is offset 350 m (1150 ft) northwest by an unexposed northeast-trending pre-intrusive fault known as Valley fault (Fig. 3). A strong reverse fault striking parallel to the trend of folding (N 40° W) and dipping to the southwest, outcrops 500 m (1650 ft) west of the nearest mineralized showings.

Detailed surface geological mapping and diamond drilling indicates that the main quartz monzonite intrusive is sill-shaped or semi-laccolithic, branching off from an irregular northeast-trending feeder dike 100 to 300 m (350 to 1000 ft) wide (Fig. 4). This feeder was probably emplaced along the Valley fault zone (Fig. 4).

Shaly beds were selectively metamorphosed to porcellanite (diopside rock) extending several hundred meters out from the marble and garnet contacts. Garnet is the dominant contact silicate. According to G. C. Amstutz its average index of refraction (higher than 1.79) suggests an intermediate composition between grossularite and andradite. The main garnetite body at the Antamina dome is exposed around the southern half of the intrusive (Fig. 3) as an elliptical arch 1700 m long. The thick-

ness of the garnet above the laccolithic intrusive (Fig. 4) is 200 to 350 m (650 to 1150 ft). At present very little is known about the extension and thickness of garnetite underneath this concordant intrusive body. However, there are evidences that garnetization continues south, outside the Antamina dome, along the dike feeder that follows the trend of the Valley fault zone. Nearly 1500 m (5000 ft) southwest of the center of the Antamina dome, an irregular garnetite zone (the Usupallares area) is exposed. This zone is related to narrow quartz monzonite porphyry dikes and sills that might be also connected to the main dike along the Valley fault.

Wollastonite is next after garnet in order of abundance but is earlier than the garnetization. Actinolite and tremolite are of local occurrence. Scapolite crystals are rare. Magnetite is contemporaneous to slightly later than garnet but earlier than the sulfides. Pyrite, chalcopyrite, and sphalerite are the most abundant sulfide minerals within the garnetite. Molybdenite, galena, and scheelite are present in subordinate amounts.

The filling of open spaces with slight replacement of garnet (Fig. 5) controlled the sulfide deposition. Post-garnet fracturing and coarse grained garnetite guided the distribution of sulfides. For instance, the largest high grade orebody so far disclosed by exploration is a chimney-shaped body localized at the intersection of strong sheeting, striking N 75° to 80° W and dipping 65° to 75° S, with a belt of coarsely crystallized garnet striking N 40° W and dipping 70° to 75° NE. In plan (Fig. 6), the orebody is elongated along the strike of sheeting, but in sections its plunge is nearly parallel to the dip of the coarse garnet belt. Since the coarse grained belt corresponds in position to the projection of the axial plane of an overturned secondary anticline exposed immediately above the garnetite contact (Fig. 3), the writer believes that this belt probably represents an inherited structure, namely, pre-existing shattering along the axial zone of the secondary anticline.

A subsequent hydrothermal stage introduced further complications. Quartz, calcite, and a second generation of pyrite filled fractures accompanied by chlorite, epidote, and the albite alteration of the garnetite. Certain areas were strongly chloritized and pyritized, but it has been found that these areas are generally lean. Moderate quartz-sericite-chlorite alteration, with pyrite and small amounts of chalcopyrite mineralization, occur in the main quartz monzonite intrusive. Pyrite, galena, sphalerite, tetrahedrite, some chalcopyrite, quartz, fluorite, and rhodocrosite fill fractures within sericitized quartz monzonite dikes or sills in the outlying areas of the district. Sulfides also occur in fractures following the contacts of these minor intrusives with marmorized and slightly silicated and silicified limestone. Sulfide mineralization, associated with hydrothermal alteration in fringing intrusives, is tentatively regarded as mesothermal.

The Morococha District: This district lies in central Peru, in the Province of Yauli, Department of Junin, at 11° 35′ S 76° 11′ W, and close to the Continental Divide at elevations ranging from 4500 to 5000 m (15,000 to 16,600 ft).

The petrology of contact metamorphism and metasomatism and the modifications introduced by

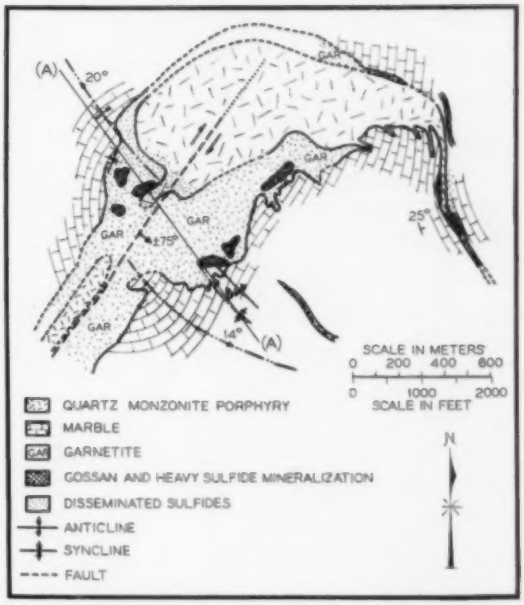

Fig. 3—Surface geology of the Antamina district, Peru. (After A. J. Terrones and U. Petersen.)

subsequent hydrothermal activity at Morococha were first recognized and studied in detail a number of years ago.[9]

The intrusive stage at Morococha started with the injection of a large diorite stock, oval-shaped in plan, elongated in the N 25° W direction. Its longer axis is nearly 6 km (3.5 miles) and the minor axis measures about 4 km (2.5 miles). After the diorite smaller stocks of granodiorite to quartz monzonite composition were intruded.

Marble, with little or no silicates, is the prevailing contact effect around the diorite intrusion. This is in sharp contrast with the extensive tactite belt of anhydrous silicates surrounding the comparatively smaller quartz monzonite stocks. Stratigraphic control of the distribution of marble and contact silicates is marked. The author[10] recognized on the surface the following horizons, from top to bottom, of the Potosi limestone (Jurassic, Lias) which surrounds these stocks. The sedimentary characteristics and corresponding contact effects are:

1) Horizon *D*: 62 to 108 m (205 to 355 ft) of thin-bedded, limy, and sandy shales grading down the column to purplish, mottled, sandy, and limy shales alternating with chert layers. This horizon is entirely silicated to porcellanite up to 1100 or 1300 m (3500 to 4500 ft) away from intrusive contacts (Fig. 7). From there on, only the uppermost calcareous portion remains silicated for 1000 m (3000 ft) more, until silification practically fades out at 2500 m (8000 ft) outward from the monzonitic intrusions.

2) Laura Horizon: 110 m (360 ft) of dolomitic limestone with chert nodules and a few shaly and sandy beds including a 5-m (16-ft) thick trachyte flow. Fresh limestone begins to grade into marble 300 to 350 m (1000 to 1150 ft) from the nearest intrusive contact. Cherty nodules and shaly layers are selectively silicated to diopside rock. Garnet and

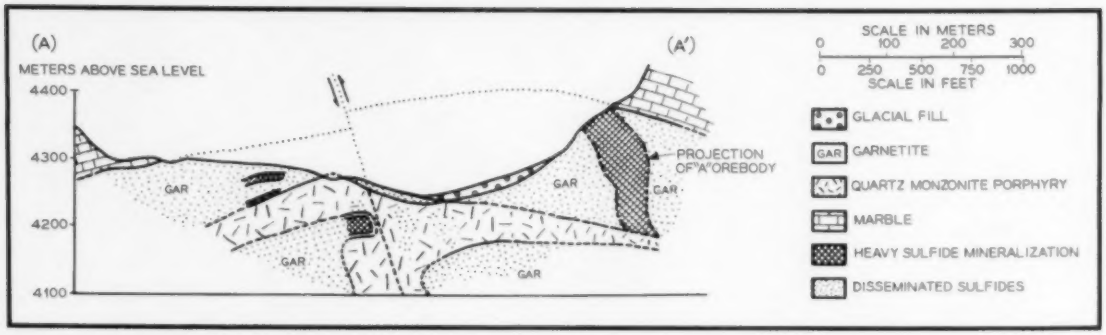

Fig. 4—Cross section (A-A'), looking northeast, Antamina district, Peru. (After A. J. Terrones and U. Petersen.)

tremolite occur only within 150 m (500 ft) of the intrusives. Magnetite occurrences are restricted to hydrated garnet-tremolite layers within the marble horizons, tending to disappear 200 m (650 ft) from the monzonite contact.

3) Horizon *E*: 26 m (85 ft) of medium to coarse grained sandstone and shaly beds with an interbedded fossiliferous dolomitic limestone bed with chert nodules. The entire horizon is thoroughly silicated within 150 m (500 ft) of the intrusive contacts, with garnet lenses replacing porcelainized beds. Only the sandy, shaly, and cherty members are selectively silicated more than 1000 m (3000 ft) away from the intrusive. The dolomitic limestone remains marmorized up to 300 m (1000 ft) from the quartz monzonite contacts.

Widespread and intense hydrothermal activity masked, and at places completely obliterated, the products of contact metasomatism. Only after detail mapping was it possible to recognize aggregates of grossularite and tremolite containing fair amounts of pyrite, pyrrhotite, sphalerite, chalcopyrite, and molybdenite as disseminated grains, blebs, and minor stringers which escaped the flooding of hydrothermal solutions. Outside these remnants it is very difficult to differentiate original contact metasomatic ore from ore mineralization deposited during the overlapping hydrothermal stage. While this latter process was under way, large volumes of contact silicates were altered (hydrated) to serpentine, chlorite, and talc. Apparently serpentine is earlier than the chlorite-talc alteration. Talc seems to be closely related to the deposition of sulfides belonging to the hydrothermal stage.

Serpentine shows a preference to replace the layers of diopside (porcellanite) rock, thus forming layered ore structures. Haapala concludes[11] that the underlying serpentine is almost contemporaneous with magnetite. The writer doubts this and believes that magnetite is a residual product from the much earlier contact metasomatic stage.

The Vilca Prospect: Small bodies of oxidized lead-zinc-silver ore occur along seven garnetized beds of Machay limestone (Middle Cretaceous), alternating with porcellanite and marble beds in an overturned anticline. This small prospect, near Vilca in Central Peru (12° 08' S, 75° 08' W), is of interest because of the remarkable selectivity of garnetization along porcellanite beds and because of the localization of ore pockets within the garnetite beds in the axial zone of the anticline.

A large diorite stock intruding a major anticline is exposed 2 km (1.25 miles) south but a quartz diorite porphyry sill nearly 1000 m (3000 ft) southeast is the nearest intrusion. Neither intrusive shows important garnetite. Each limb of the anticline is cut by a steep, nearly east-west trending fault. It is postulated that an underlying monzonitic body, intruded along the downward extensions of the east-west faults, is responsible for the garnetization and sulfide minerlization.

Disseminated pyrite and galena, with minor amounts of tetrahedrite and sphalerite, form small pockets of low grade ore in the shattered garnetite beds at the apex of the fold. Detail mapping shows that this mineralization follows fractures parallel to the bedding, preferably along the contacts with bordering porcellanite beds (Fig. 8). Some of these mineralized fractures cut across the silicated beds and form small replacement bodies in the marble layers. Fracturing or shattering of the more brittle porcelainized beds probably favored the selective replacement by garnet and sulfides.

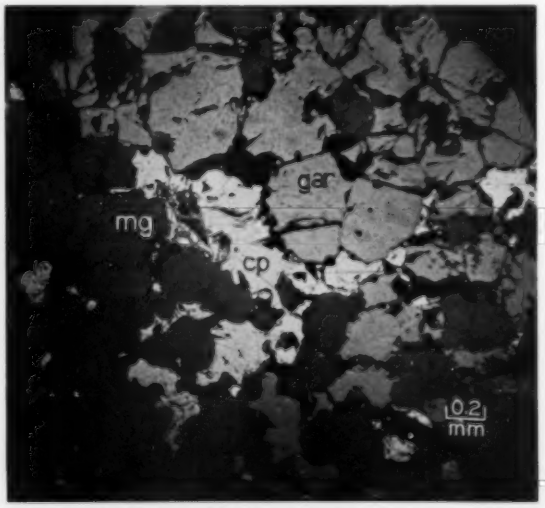

Fig. 5—Chalcopyrite (white) filling interstitial spaces between earlier garnet (gray) and magnetite (black) at the Antamina copper deposit, Peru. X40.

The Ferrobamba District: The Ferrobamba, Charcas, Chalcobamba, and Sulfobamba deposits comprise this district, which extends 13 km (8 miles) along an east-west trending belt with center 14° 04′ S 72° 22′ W, 83 km (5.5 air miles) southwest of Cusco in the Department of Apurimac.

Regional investigations by W. F. Jenks[12] showed that the lower half of the Cretaceous Ferrobamba limestone was intruded by stocks of granodiorite, monzonite, quartz monzonite, and diorite. Larger dioritic stocks appear to be elongated along major axis of structural deformation.

Coarse marble is the dominant contact effect in practically all types of intrusives. Garnet, epidote, and wollastonite are restricted to the more acidic intrusions. F. C. Kruger[10] reported that magnetite and coarse specularite occur invariably interlayered with contact silicates. Chalcopyrite is more abundant than pyrrhotite and bornite, occurring as blebs, pods, or layers along relict bedding planes or disseminated in massive magnetite. It became evident, from mapping, that chalcopyrite mineralization is intimately associated with impure banded mixtures of contact silicates rather than with purer garnet or epidote. At Charcas, Kruger[10] noticed that chalcopyrite-pyrrhotite mineralization is in general concordant with bedding, but at the other deposits in the district it cuts across stratification following joints or irregular fractures. Sulfides at this locality were found to be in part contemporaneous and in part later than magnetite. The reported occurrence of chlorite at Chalcobamba suggests the existence of an incipient hydrothermal stage.

Jenks[12] summarizes the major factors controlling the location of copper orebodies in the Ferrobamba region as follows:

1. The presence of the Ferrobamba limestone, particularly the basal half of the formation.

2. The presence of monzonite or quartz monzonite in contract with the limestone and occurring as small stock or apophyses within or from large diorite masses. (Monzonite dikes or small monzonite stocks, not directly associated with large diorite intrusives, do not seem to have brought in copper values or even formed appreciable amounts of garnet.)

3. The presence of cross folds at high angle to regional trends and apparently due to crumpling at culminations and depressions of plunging folds.

The Katanga (Quibio) Prospect: At this prospect, 82 km (51 miles) southeast of Ferrobamba, hornblende diorite and quartz diorite porphyry stocks intruded dark gray, finely banded, mottled Ferrobamba limestone beds that alternate with thin-bedded shales and sandstones. Coarse marble selectively follows the limestone horizons, whereas contact silicates (mainly pyroxene) replace the more shaly members. Lenticular masses of hematite-magnetite up to 25 m (80 ft) thick occur only around the hornblende diorite stock (Quibio hill).

Garnet-tremolite lenses with magnetite, specularite, pyrite, and oxidized chalcopyrite mineralization occur as elongated endomorphic replacements in quartz diorite porphyry along fractures or zones of brecciation parallel to the intrusive contact. Outside the porphyry, steep plunging lenticular bodies with the same mineral composition are localized between quartz diorite and marble containing chloritized silicates. These lenses essentially follow the attitude of bedding.

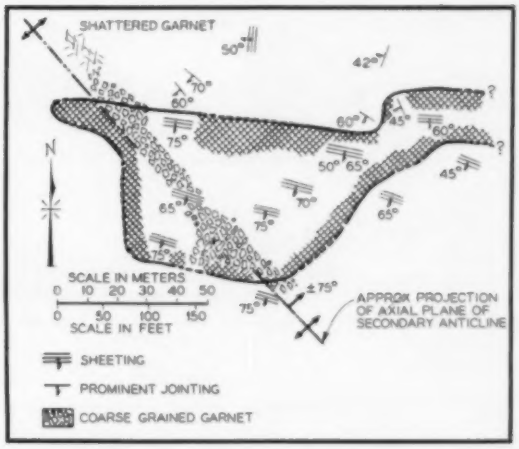

Fig. 6—Structural map of the A orebody on level A, Antamina district, Peru.

No garnet-tremolite and associated sulfides were noticed along the hornblende diorite contacts. Slight quartz-sericite alteration in the quartz porphyry, as well as chloritization of contact silicates, indicates a mild, post-ore hydrothermal activity.

The Tintaya District: The Tintaya district lies in the province of Espinar, Cusco Department, at 14° 47′ S, 71° 20′ W, and 4000 m (13,000 ft) above sea level.

An augite diorite stock and a later monzonite porphyry differentiate intruded Jurrassic (Portlandian) quartzites and middle Cretaceous (Cenomanian) limestone beds. The diorite is the largest intrusive in the district, about 9x5 km (5.5x3 miles), showing a definite elongation in the NW-SE direction, parallel to the major tectonic axis. The monzonite porphyry stock is much smaller—more than 2 km (1.2 miles) long by 1 to 2 km (0.6 to 1.2 miles) wide—and was emplaced at the northern extremity of the diorite stock. Numerous dikes and sills protrude from the southern border of the monzonite, cutting across an intervening block of limestone 300 to 500 m (1000 to 1650 ft) wide, which separates both stocks. Some of these dikes cut across the earlier diorite intrusive.

Cross folds and faults trending northeast or east-northeast, nearly at right angles to lines of structural deformation, were mapped in the outskirts of the district. A northeast-trending fault is tangent to the southeast border of the monzonite stock. It is interesting to note that the southern portion of this stock and major branching dikes (Fig. 9) are elongated parallel to the trend of east-northeast cross structures. No cross folding is recognized at this particular locality. Bedding strikes persistently N 50° W and dips 30° to 45° SW (Fig. 9). Therefore cross faulting and related fracturing must have guided the emplacement of monzonite.

Coarse to fine marble, and very locally diopside rock, are the only products of contact metamorphism occurring around diorite. Garnet, magnetite, and sulfides, as the products of the metasomatic stage, were exclusively developed along monzonite contacts where coarse to fine marble occurs also.

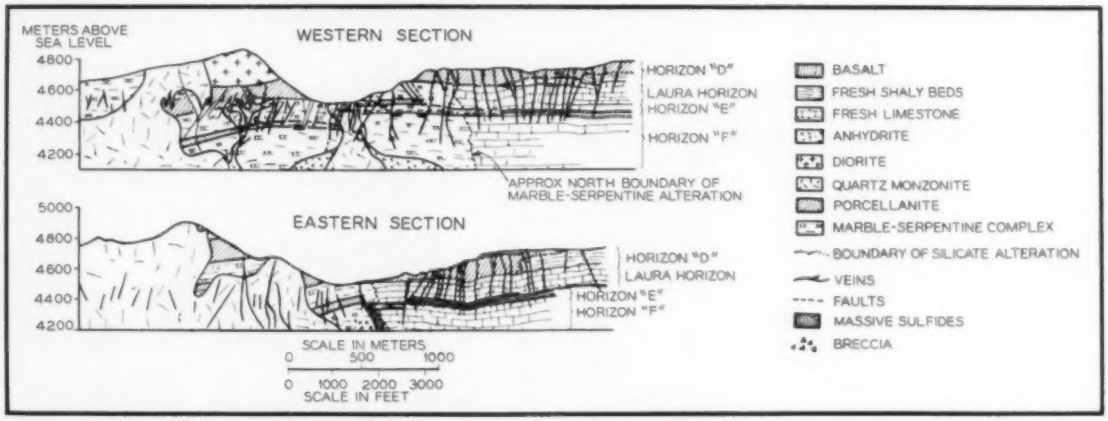

Fig. 7—North-south sections, looking west, through the north-central Morococha district, Peru, showing contact silicate alteration in relation to stratigraphy and structure.

The distribution and the shape of the garnetite are mainly controlled by the shape of the monzonite intrusive (Fig. 8) and very possibly, although to a minor extent, by the grain size in the marble. Coarse grained and wholly recrystallized limestone was more favorable for contact silicate replacement than dense and tighter, partly recrystallized, gray-black limestone.

F. de las Casas[14] describes the Tintaya garnet as an isomorphic mixture of andradite and grossularite. He also found that copper mineralization was almost invariably associated with grossularite, and concluded that this mineral "represents the last phase of garnetization when ferric iron was not available in the (replacing) solution. . . ."

Magnetite and hematite are somewhat contemporaneous and slightly later than garnet, but definitely earlier than quartz and sulfides. Quartz fills fractures in garnet and selectively replaced garnet along crystal boundaries and certain internal layers formed by crystal zoning (Fig. 10). Bornite is earlier and much less abundant than chalcopyrite, which is the main ore mineral in the sulfide zone. Sulfides were deposited in quartz stringers, filled interstitial cavities (Fig. 10), were associated with calcite veinlets, and filled tiny crystal fractures. In general, ore mineralization is more evenly distributed within garnetite than at other Peruvian deposits. However, there are indications that post-garnet shattering along monzonite and marble contacts, as well as formation of coarse grained grossularite garnet, served to concentrate copper mineralization with leaner ore localized at impervious dense garnet. Observations seem to confirm that coarse grained garnet was inherited after coarse marble beds.

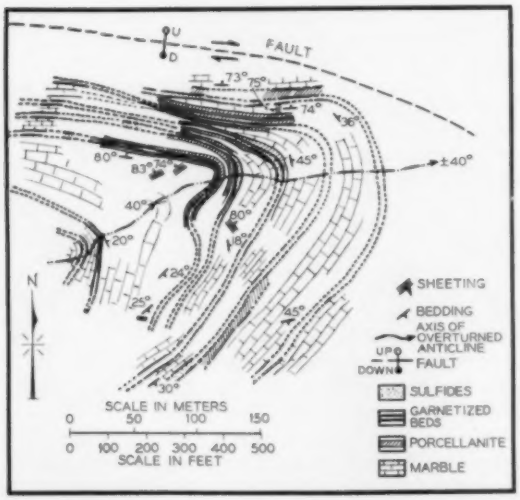

Fig. 8—Structural of map, Vilca prospect, Peru, showing selective garnetization along porcelainized beds. (After J. A. Cabieses, modified by A. J. Terrones.)

The orebodies are predominantly manto-like, although along dikes they occur as tabular or lenticular bodies cutting across bedding. Sulfides were oxidized *in situ* with little or no supergene enrichment. Chrysocolla and brochantite are the dominant oxide minerals.

Chloritization and subordinate serpentinization are locally moderate to intense, forming soft powdery material that at places collapsed to originate post-ore slump breccias. Hydration of garnet, accompanied by moderate to slight quartz-sericite-clay alteration in the monzonite intrusives, attests the existence of a mild, but barren, post-ore hydrothermal stage.

The Huarca Prospect: At this prospect, lying 10 km (6 miles) southwest of Tintaya, an irregular vein-like garnetite body, with banded oxidized chalcopyrite-bornite mineralization, is localized along a small quartz-monzonite porphyry stock.

The garnet, which replaced marble and monzonite along the contact (Fig. 11), was subsequently fractured and replaced by lenses of magnetite and cut by veins of chalcopyrite-bornite-pyrite stringers lying nearly parallel to the contact zone, producing a banded structure very much like a vein deposit. Fine grained garnetized beds, with disseminated sulfides in stringers and small grains, branch out from the contact zone along minor dikes.

The main ore zone is 1 to 10 m (3 to 30 ft) wide and is oxidized to 20 m (65 ft) below the surface. Main oxide minerals are copper carbonates, chrysocolla, and cuprite. Small amounts of supergene chalcocite are mixed with sulfide and oxide min-

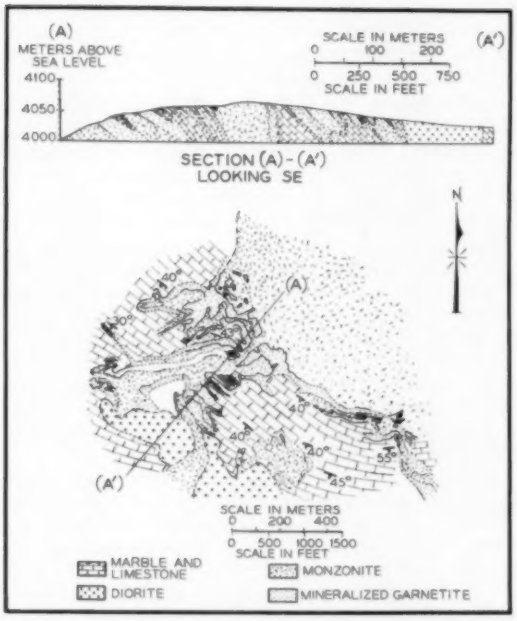

Fig. 9—Structural control of mineralized garnetite along monzonite dikes and sills, emplaced along east-northeast fracturing and northwest-trending bedding, at southwest Tintaya district, Peru.

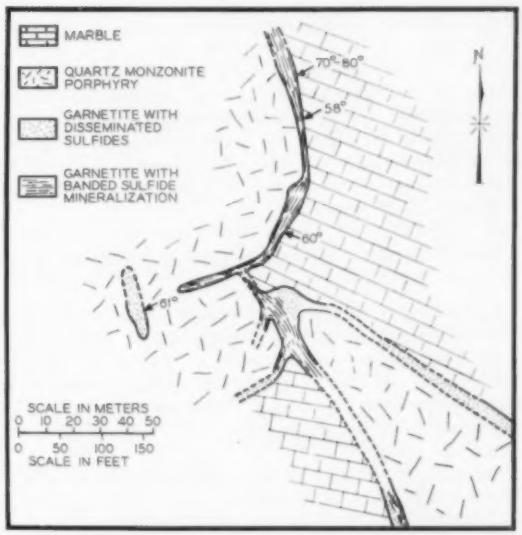

Fig. 11—Vein-like garnetite deposit along fractured quartz monzonite-marble contract at Huarca prospect, southern Peru. (After A. J. Terrones and R. H. Kimball, Jr.)

erals. Garnet was locally chloritized by subsequent hydrothermal alteration.

Conclusions

An orderly, continuous, and to a certain extent overlapping sequence of events is visualized in the evolution of geological processes that originated the contact metasomatic deposits in the Peruvian Cordillera. The entire process can be subdivided in four stages: 1) intrusive stage, 2) metamorphic stage, 3) metasomatic stage, and 4) hydrothermal stage.

Without any attempt to minimize the importance of physico-chemical controls, it is concluded that structure played a role of considerable significance throughout all four stages in determining the distribution, shape, size, concentration, and subsequent modifications of ore mineralization. Proper understanding and evaluation of the relative importance of structural features, developed and modified during the evolution of these four stages, are critical in planning intelligent exploration and mine development.

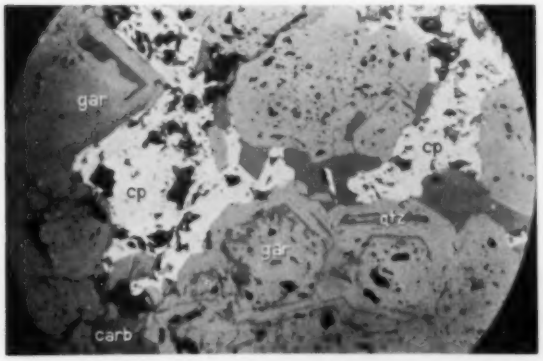

Fig. 10—Quartz (dark gray), replacing garnet crystals (light gray), following grain boundaries, small fractures, or crystal zoning. Chalcopyrite (white) fills interstitial spaces and partly replaces garnet and quartz. Tintaya copper deposit, Peru. X72.

Intrusive Stage: Magmatic differentiation from diorite to quartz monzonite or to granodiorite was essential. Garnetization and sulfide mineralization are invariably related to the intrusion of later and more acidic differentiates. This condition is well illustrated at Morococha, Ferrobamba, Katanga (Quibio), and Tintaya. No basic intrusive is exposed at Magistral, but the andesite porphyry dikes at Antamina probably represent branches of a buried diorite stock. At Vilca a large diorite stock outcrops near the ore showings, but the acidic intrusive is concealed under silicated and marmorized limestone. W. C. Lacy[15] recognized that the same process of magmatitic differentiation operated at other important mining districts in Central Peru (Cerro de Pasco, Yauricocha, Raura, and Julcani) besides Morococha and concluded that ore solutions escaped during the quartz monzonite phase.

Pre-intrusion structures determined, to a certain extent, the final shape of stocks and minor intrusive bodies. Earlier diorite stocks at Morococha, Ferrobamba, and Tintaya are elongated parallel to major tectonic axes, whereas the emplacement of later monzonitic intrusives seemed to prefer cross folding or fracturing at right angles to this direction. The east-northeast elongation of the Magistral quartz monzonite stock, the intrusion of the quartz monzonite dike feeder at Antamina along the northeast-trending Valley fault, the monzonitic intrusions along cross folding at Ferrobamba, and the east-northeast elongation of the southern portion of the Tintaya monzonite stock and dikes are evidences pointing to a predominance of cross-trending structural control in the intrusion of acidic differentiates. This structural preference is explained by:

1) Pre-existing minor cross folds, shears and fractures, oriented nearly at right angles to regional tensional stresses, caused by the stretching of longitudinal folds under active northeast-southwest

compression. These cross structures were the loci of least resistance at the surge of the intrusive stage.

2) Arching or bending of folded structures, caused by the vertical upward stresses of intruding diorite stocks, which reactivated tensional stresses perpendicular to the east-northeast direction, forced apart pre-existing lines of least resistance. Tension fractures and northeast-trending shears were opened while shattering or brecciation occurred along the axial planes of cross folds.

3) Injection of acidic differentiates into well prepared ground, dominantly along weaker east-northeast trending belts.

Metamorphic Stage: Marble and porcellanite were developed under rising temperature conditions. Their distribution and shape were guided by stratigraphy and by pre-existent structure. Marble is controlled by the position of limestone beds, whereas porcellanite (diopside rock) follows the more shaly and siliceous beds.

Porcellanite persists much farther away from intrusive contacts than marble. This is clearly shown at Magistral, Antamina, and Morococha.

Metasomatic Stage: Garnet is superimposed over marble and porcellanite and is the dominant silicate mineral within the tactite zone surrounding acidic intrusives. Wollastonite was proved to be earlier than garnet at Antamina and Morococha. Fair amounts of epidote were noticed at Ferrobamba. Tremolite occurs everywhere in subordinate amounts and scapolite is rare. Garnet, replacing marble beds, tends to produce granular textures, whereas felsitic or dense garnet predominates along porcellanite beds. There are evidences at Morococha and Vilca that fracturing in porcellanite contributed to localize garnetization in silicated beds.

Magnetite overlaps garnet but appears to be earlier than quartz and introduced calcite. Fairly large bodies of hematite-magnetite border the diorite intrusives at Ferrobamba, Katanga (Quibio), and Tintaya. Sulfides overlap quartz and appear to be definitely later than magnetite.

Distribution of highly pervious coarse garnet and post-garnet fracturing controlled the shape and size of both massive and disseminated sulfide orebodies. Distribution of coarse garnet, which provided ore-solution channelways, was caused by:

1) Selective metasomatic replacement of coarser marble beds (Magistral, Antamina, Morococha, and Ferrobamba). In this case the garnet inherited the original grain size of marble beds.

2) Free crystal growth at open cavities in strongly shattered, brecciated, or fractured marble and porcellanite. The attitude of some of the more regular bodies of coarse grained garnet might reflect the trend of pre-skarn structural features (Magistral, Antamina, Vilca, Katanga and Tintaya), such as shattering or brecciation along projections of tight folds (Antamina), or of prominent fracturing.

Chalcopyrite is the dominant sulfide mineral. Pyrrhotite, bornite, pyrite, sphalerite (marmatitic), and galena come next in order of abundance. Molybdenite is locally important (Antamina) and scheelite forms only spotty concentrations near marble contacts (Antamina and Morococha).

Sulfides occupy interstitial cavities between garnet crystals or fill fractures ranging in size from tiny crystal cracks to wide fracture zones, most of them located near or at the garnetite contacts. At Antamina and Tintaya, sulfides occur throughout the entire volume of garnetite. At Magistral, Vilca, Katanga (Quibio), and Huarca the sulfide mineralization tends to be more localized by fracturing along the garnetite borders.

Hydrothermal Stage: There are evidences that hydrothermal activity followed the pneumatolitic stage that caused the contact metasomatic silicate-oxide-sulfide replacements. The degree of intensity of this last stage is variable, ranging from very slight at Magistral to highly intense at Morococha.

Sulfide deposition usually accompanied the hydrothermal stage. It may have been minor, but in some cases new and important commercial orebodies orginated, superimposed upon older contact metasomatic ore mineralization. Best examples of this overlapping condition are found at Antamina and at north-central Morococha. The recognition of both types of ore mineralization requires detailed and careful geological mapping in conjunction with systematic petrographic investigation.

The hydrothermal stage might completely obliterate the original structure of contact metasomatic orebodies, and even careful mapping would be entirely ineffective in an attempt to reconstruct the original contact metasomatic ore structures. Fortunately it seems that this happened only in extreme cases, and detailed mapping of anhydrous and hydrated silicates usually reveals the original pattern of contact metasomatic mineralization. Even mild cases of superimposed hydrothermal alteration may locally introduce a different structural setting at contact metasomatic orebodies, such as the post-ore slumping and brecciation, recognized at Tintaya, caused by local weakening of garnetite after hydrothermal alteration.

Acknowledgments

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References

[1] W. Lindgren: *Mineral Deposits*, pp. 695-745. McGraw-Hill Book Co. Inc., New York, 1933.
[2] J. Barrell: Geology of the Marysville Mining District, Montana. *USGS Prof. Paper*, pp. 116-150, 1905.
[3] V. M. Goldschmidt: *Die Kontactmetamorphose in Kristianiagebiet*, 1911. (Reference from Lindgren, p. 705).
[4] A. Knopf: Ore Deposits of the Western States: Lindgren volume, 1942. *AIME*, pp. 537-557.
[5] A. Knopf: *Ore Deposits as Related to Structural Features*. Edited by W. H. Newhouse, Princeton University Press, 1942.
[6] H. Schmitt: The Contact Pyrometasomatic Aureoles. *AIME TP 2357*, 1948.
[7] D. H. McLaughlin: Personal communication.
[8] A. J. Bodenlos and G. E. Ericksen: Lead-Zinc Deposits Cordillera Blanca and Northern Cordillera Huayhuash, Peru: *USGS Bull.* 1017, pp. 89-100, 1955.
[9] T. G. Moore: The Geology and Ore Deposits of Morococha, Peru. Doctoral dessertation, Harvard University, 1936.
[10] A. J. Terrones: Estratigrafia del distrito o miner de Morococha. Sociedad Geologica del Peru, *Volumen Jubilar*, XXV Aniversario, Parte II, Faciculo 8, pp. 8-9, 1949.
[11] P. S. Haapala: *Morococha Anhydrite. Boletin de la Sociedad Geologica del Peru*, 1953, vol. 26 (Broggi Volume), pp. 21-32.
[12] W. F. Jenks: Personal communication.
[13] F. C. Kruger: Personal communication.
[14] F. de las Casas: Personal communication.
[15] W. C. Lacy: Differentiation of Igneous Rocks and Its Relation to Ore Deposition in Central Peru. *Boletin de la Sociedad Geologica del Peru*, 1953, vol. 26 (Broggi volume), pp. 121-134.

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Relation of Magnetic Susceptibility to Mineral Composition

There is evidence that study of minerals now considered to have susceptibilities too low for magnetic separation should be continued. Present concepts may be false.

by Ernest M. Spokes and David R. Mitchell

INFORMATION on magnetic properties of minerals other than magnetite is scanty and sometimes erroneous. Often there is no information at all. W. R. Crane's table of tractive forces published in 1901 is still the best guide in the field, but Crane's data can be used as a guide only, since he ignored such important factors as impurities in the minerals, size, and packing effect. During the 1930's work by the U. S. Bureau of Mines added greatly to knowledge of the behavior of certain minerals in a magnetic field. The USBM bulletin gave for the first time complete magnetic characteristics for magnetite and fragmentary data for a few other minerals.

The work reported here covers a study of the magnetic-susceptibility relationships of the wolframite series of minerals and sphalerites as related to their chemical compositions. Theories are proposed to explain divergences found from commonly accepted beliefs.

Gouy Method for Determining Magnetic Susceptibility: The Gouy principle has been adequately described in the literature[1-3] and applied in various ways.[4-6] It may be summarized by stating that a body of material (gas, liquid, solid, or powder mixed with gas or liquid) of cylindrical shape changes in apparent weight if suspended with one end in a zone of higher magnetic field strength than is found in that portion of the field surrounding the other end of the cylinder. This may be expressed as

$$\frac{K_2 - K_1}{2} A(H^2 - H_0^2) = mg. \qquad [1]$$

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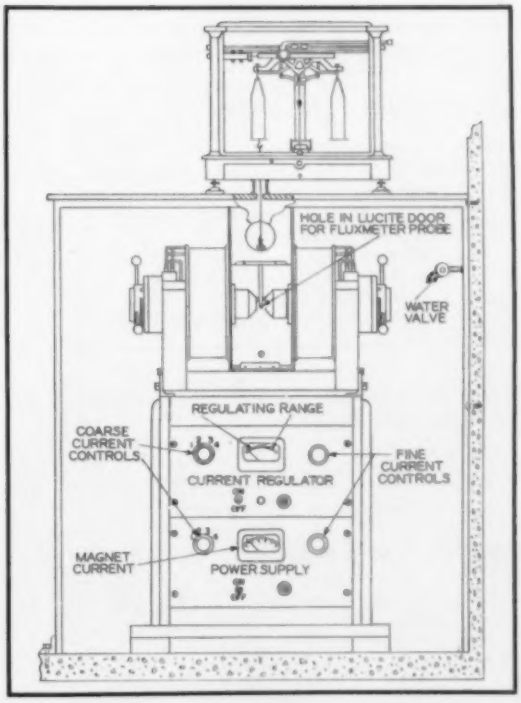

Fig. 1—Arrangement of balance and magnet.

In determining the susceptibility of mineral specimens by the Gouy method, the mineral is reduced to a fine powder and packed in a glass weighing tube. Precise measurement of the bore and depth of the tube is made unnecessary by a calibration procedure. Using the basic expression of Eq. 1, Hoare[6]

Definition of Terms Used in Equations

A : cross-sectional area of test cylinder.
H : higher value of the field strength at cylinder ends.
H_o: lower value of the field strength at cylinder ends.
m: weight change of a test cylinder, in grams.
g : acceleration of gravity.
C : a constant, equal to $\frac{1}{2g}$.
W: weight of water in a weighing tube.
c : weight of water in the meniscus in a tube.
L : length of column of water below the meniscus.
L': length of a weighing tube.
d : density of water at ambient temperature.
f_1 : a constant for a given field strength, pertaining to specimens in weighing tubes, nominally equal to $1 - \frac{H_o^2}{H^2}$
f_2 : a similar constant pertaining to the weighing tubes themselves.
N : a constant applying to the space occupied by a sample in a given weighing tube, defined in Eq. 5.
P : a constant applying to the tube itself, defined in Eq. 9.
S : weight of sample in weighing tube.
s : density of corresponding mineral.
T : weight of a glass weighing tube.
t : density of the glass.
$\delta W, \delta S, \delta T$: changes in the corresponding weights when observed in a magnetic field.
K : the volume susceptibility of a substance, equal to the intensity, I, of magnetism in the substance divided by the strength of the field producing that magnetism. The substance is identified by subscripts:
1. medium surrounding a sample
2. material being tested
w. water
a. air
s. a sample
t. the glass of a weighing tube.

derived Eq. 2 for the calibration of weighing tubes with water as a standard:

$$\delta W = \frac{C(W-c)}{dL}(K_w - K_a)(H^2 - H_o^2). \qquad [2]$$

At any given field strength, for a fixed value of L,

$$H^2 - H_o^2 = H^2\left(1 - \frac{H_o^2}{H^2}\right) = f_1 H^2. \qquad [3]$$

Substituting Eq. 3 in Eq. 2 obtains

$$\delta W = \frac{C(W-c)}{dL}(K_w - K_a) f_1 H^2. \qquad [4]$$

The calibration characteristic of the tube is now defined:

$$N = \frac{C}{L} = \frac{\delta W}{(W-c)} \frac{d}{f_1 H^2 (K_w - K_a)}. \qquad [5]$$

Hoare's equation for finding the susceptibility of a salt (or other powdered material) may be expressed as

$$\delta S = \frac{C(H^2 - H_o^2)}{L} \frac{S}{s}(K_s - K_a). \qquad [6]$$

From this it is evident that

$$K_s = K_a + \frac{\delta S}{f_1 H^2} \frac{s}{NS}. \qquad [7]$$

Since the glass of the weighing tubes has a volume susceptibility different from that of the surrounding air, application of the magnetic field causes a weight change in the tube as well as in the contents. By analogy, then, the following equations are established from Eqs. 2 and 5:

$$\delta T = \frac{C'T}{tL'}(K_t - K_a)(H^2 - H_o^2). \qquad [8]$$

The constant P is used during calibration of the equipment to assist in averaging the values of f_2 and δT. It is defined by

$$P = \frac{CT}{tL'}(K_t - K_a) \qquad [9]$$

and is obtained by using the relationship

$$P = \frac{\delta T}{f_2 H^2}. \qquad [10]$$

The constants f_1 and f_2 are determined experimentally by methods described later. Any instrumental error in the field strength measurement is absorbed in the values of these constants when they are determined for the different values of H. It should be noted that since L' is greater than L, H_o does not bear the same relationship to H in f_1 as it does in f_2, and so these two constants are not the same numerically.

The specific susceptibility is calculated from Eq. 11:

$$X_s = \frac{K_s}{s} \qquad [11]$$

Magnetic Balance and Accessory Equipment: For the magnet, a Varian Model V-4004 4-in. electromagnet, water cooled, with V-2300 power supply and V-2301 current regulator was used. Pole pieces tapered to 2-in. diam were selected because they gave a larger field strength than untapered poles or those tapered to 3 in.; the advantage, as compared with pointed poles or poles having 1-in. diam faces, was a field of uniform strength for enough distance from the magnet axis to allow for minor discrepancies in positioning the test samples and to provide space for the probe of a Rawson Lush Fluxmeter for measuring and monitoring the strength of the magnetic field.

An Ainsworth Type TY semi-micro analytical balance with magnetic damper was used for the weighings. It was modified at the factory for weighing suspended loads and was mounted over the magnet as shown in Fig. 1.

For magnet weighings a piece of gold locket-chain, with a ring at the upper end and a hook at the lower, was hung from the left pan. A support disk of thin aluminum was attached to the hook.

A piece of pyrex glass tubing, 8 mm OD by 14.8 cm long, was used for each weighing tube. One end was closed and the other flared so that it resembled a test tube. The flaring was carefully positioned so that the tube, when placed in the slot in the aluminum disk, would hang with the inside of the bottom at the axis of the magnet poles. After flaring, the tops were ground flat and loosely fitting aluminum stoppers were made. Each tube was inscribed at 10, 11, and 12-cm depth (only the last depth was actually used), and each tube and corresponding stopper was lettered to match.

Specimen Preparation and Handling: Specimens were identified by place of origin whenever this was known. To obtain the most precise values possible, careful preparation of the specimens was required. With one exception (Climax wolframite), each sample was hand-picked to remove excess waste after being broken to about ¼ in. It was then crushed to pass a 48 mesh screen. The Climax sample, a concentrate of about 100 pct −65 mesh, was treated in the same manner as the other specimens from this point. The material was then screened to +100, 100 to 200, 200 to 270, and −270 mesh fractions. The smallest fraction was discarded as being too fine for effective concentration by the magnetic and gravity processes that followed.

An Isodynamic separator, Model L1, was used to eliminate highly magnetic minerals such as magnetite from all specimens, and, from the wolframite series and the magnetic sphalerites, the gangue of low attractability. A special technique was developed for preparation of small quantities of concentrate of higher purity.

The wolframite group was next cleaned with acid to remove soluble gangue minerals, including sulfides and carbonates.* After 4 cc of concentrated nitric acid per gram of sample were added to the mineral, it was held at a low boil in a hood for 10 min, the acid was decanted immediately, and the remaining solids were washed several times with distilled water and dried. From this point on, all specimens were treated alike.

The dry mineral was next screened on the following Tyler sieves: 65, 100, 115, 150, 170, 200, 250, and 270 mesh. Each size fraction was then further cleaned separately in a free-settling classifier. The rising current was adjusted to cause a small part of the material to overflow while the bulk settled in the column. The settled product was examined on the petrographic microscope for remaining gangue, and it was recleaned if there appeared to be an excessive quantity.

The density of each specimen was measured by taking up to 18 g of the largest size particles—usually larger than 100 mesh—and making at least two determinations with a pycnometer. An agreement within 1 pct was sought.

The cleaned specimens were ground in a mullite mortar on a Fisher mortar grinder until all would pass through a 270 mesh sieve. The ground sample

* Although Dana[7] states that wolframite is insoluble in acids, some solubility in hydrochloric acid was noted and is possibly a function of composition.

Table I. Magnetic Characteristics and Chemical Composition of Minerals in the Wolframite Series

Origin	Susceptibility*		Density	Chemical Analysis, Pct			Spectrographic Analysis, Pct**				
	Specific	Volume		Fe	Mn	W	Co	Ni	Al	Ba	Be
Huebnerites: iron to manganese atomic equivalent ratio less than 1:4											
North Carolina	36.83±0.11	261.3	7.096	0.34	17.25	58.68	—	0.03	0.04	—	—
Mexico	35.87±0.17	251.5	7.012	0.53	16.67	55.46	0.06	0.045	0.17	—	—
Wolframites: iron to manganese atomic equivalent ratio from 1:4 to 4:1											
Korea	36.50±0.17	261.3	7.161	4.08	11.19	58.47	—	0.04	0.04	0.02	—
Climax	35.94±0.13	249.3	6.937	5.82	11.17	59.04	—	0.04	0.2	0.02	—
Silverton	35.60±0.73	257.4	7.231	5.96	10.71	56.57	—	0.03	0.04	—	—
China	35.57±0.20	256.5	7.266	9.10	8.05	58.49	<0.008	0.035	0.02	0.02	—
Sweden	34.27±0.06	242.4	7.074	9.89	7.62	58.30	—	0.04	0.035	0.02	0.00017
England	35.66±0.16	256.8	7.200	10.63	6.58	55.79	—	0.035	0.025	0.02	0.00011
France	35.00±0.25	247.3	7.065	12.79	5.22	59.26	—	0.035	0.16	0.02	—
Unknown	31.75±0.21	217.1	6.838	13.53	3.96	56.45	—	0.03	0.14	0.02	0.0007
Ferberites: iron to manganese atomic equivalent ratio greater than 4:1											
Peru	33.33±0.23	242.7	7.284	15.74	2.20	56.55	—	0.035	0.02	0.08	—
Malaya	35.25±0.23	253.1	7.180	17.22	1.64	59.37	—	0.035	0.018	0.025	—
Nederland—A	32.92±0.10	210.3	6.388	17.70	0.75	56.95	0.02	0.035	0.25	0.04	—
Nederland—B	33.39±0.08	212.4	6.360	16.83	0.40	57.68	—	0.03	0.1	0.02	—

Origin	Spectrographic Analysis, Pct**											
	Ca	Cr	Cu	Mg	Pb	Si	Sn	Sr	Ti	V	Zn	Zr
Huebnerites: iron to manganese atomic equivalent ratio less than 1:4												
North Carolina	—	—	—	0.035	—	<0.05	—	—	0.011	—	—	<0.001
Mexico	0.35	—	0.04	0.1	0.025	—	0.14	—	0.02	—	—	<0.002
Wolframites: iron to manganese atomic equivalent ratio from 1:4 to 4:1												
Korea	0.2	<0.001	0.008	0.045	0.1	—	—	—	0.055	—	—	0.0055
Climax	0.18	0.002	0.018	0.12	0.25	0.4	—	—	0.25	—	0.055	0.025
Silverton	<0.18	—	0.007	0.013	—	0.08	<0.04	—	0.008	—	<0.03	<0.003
China	0.19	0.002	0.013	0.01	0.09	—	<0.04	—	<0.004	—	0.07	0.012
Sweden	0.4	0.0014	0.014	0.20	0.11	—	0.05	—	0.013	—	0.09	0.015
England	0.3	0.0035	0.035	0.035	—	0.08	—	0.006	0.014	—	<0.001	0.011
France	0.35	<0.002	0.04	0.05	0.045	0.55	—	—	0.015	—	0.045	0.01
Unknown	0.3	<0.002	6.	0.013	0.03	0.25	0.045	—	0.014	—	<0.006	0.007
Ferberites: iron to manganese atomic equivalent ratio greater than 4:1												
Peru	0.35	0.008	0.06	0.12	2.5	<0.05	—	0.006	0.05	0.095	1.	0.016
Malaya	0.35	0.005	0.013	0.075	0.04	—	0.055	—	0.05	—	—	0.013
Nederland—A	0.5	0.005	0.1	0.055	0.13	3.	0.06	0.006	0.05	0.095	0.1	0.013
Nederland—B	0.5	0.007	0.005	0.035	0.04	3.	0.045	0.006	0.05	0.095	0.035	0.016

* Susceptibility is in cgsm units x 10^6. Susceptibility values are an average of observations at 10,000, 15,000, 19,000, and 21,000 oersteds.
** As and Mo were not detected in any specimens. Ag was not found except 0.005 pct in the Peruvian wolframite; Nederland *A* contained 0.085 pct Sb, not observed in the others.
Dashes indicate that an element was not detected in concentrations within the sensitivity of the method used and the line observed.

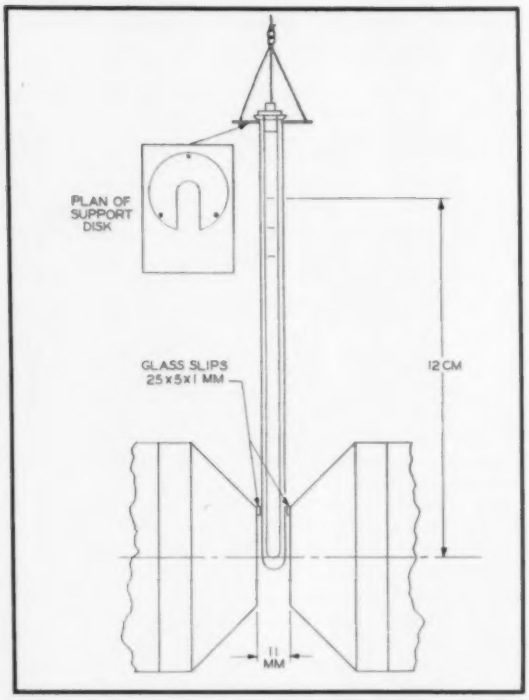

Fig. 2—Weighing tube suspension details.

was placed in a plastic vial 1 in. diam by 2 in. long, with a glass baffle 11/16 in. wide, 3/16 in. thick, and 1 15/16 in. long fastened in the cap. It was then placed in a large-mouthed jar on rotating rollers and mixed for a minimum of 4 hr.

The mineral powder was transferred from storage vial to weighing tube in a pyrex tube. The powder was added to the weighing tube in small increments and tamped solidly with a pyrex rod.

Operation of Magnetic Balance: Four calibrated weighing tubes were filled with a given specimen and weighed at null-field and at each of four field strengths. From the corrected $\delta(T + S)$ the appropriate value of δt was subtracted algebraically, leaving δS.

For convenience in calculation, Eq. 7 may be rewritten

$$\frac{K_v - K_a}{s} = \frac{\delta S}{f_1 H^2 NS}. \qquad [12]$$

The function $(K_v - K_a) \div s$ was computed for all specimens in the wolframite group

At this point a pattern that was reasonably consistent across all samples was observed in the values of the function: for any sample the figures calculated for 10,000 oersteds were the smallest, with successive increases in magnitude to those for 21,000 oersteds. This was attributed to errors in determining f_1, possibly owing to the small number of observations on which those computations were based. It is possible that the pattern was caused by a slight ferromagnetic characteristic of the mineral.

To eliminate the error, the sum of the determinations of the function for a given specimen at one field strength was divided by the average of all determinations on that specimen. All of the quotients so found for a given field strength were added together and divided by the number of individual weighings at that field. This gave factors that corrected the original f_1's when multiplied by them. The functions from Eq. 8 were adjusted accordingly.

A second pattern, related to individual weighing tubes, was next observed. This was eliminated by a similar process to correct N for each tube. The function $(K_v - K_a) \div s$ was again adjusted and was analyzed statistically for each specimen to eliminate highly divergent units. Of the 242 original weighings of wolframite group minerals, only 8 were discarded by this operation.

After elimination of the anomalous original weights, the entire calculation was repeated and the probable error determined. Multiplication by s gave $K_v - K_a$; to this K_a was added; and, finally, this last sum was divided by s to obtain X, the specific susceptibility.

In the case of the sphalerite specimens it was found that a ferromagnetic characteristic caused a variation in susceptibility with field strength. The corrected values of f_1 and N obtained in the wolframite study were used to compute $(K_v - K_a) \div s$ for each weighing, and the average of the four values at each field strength was used to determine K_v and X.

Removed from weighing tubes, the samples were analyzed by wet methods for major constituents and spectrographically for minor components. Iron, manganese, and tungsten in the wolframite group—designated as (Fe, Mn) WO_4—and zinc, sulfur, and iron in the sphalerites were considered to be major.

Wolframite Series Minerals: Data for the wolframite group are given in Table I. The iron-to-manganese atomic equivalent ratio varies from 1:52 in the huebnerite from North Carolina to 41:1 in one of the ferberites from the Nederland district in Colorado.

It may be noted that the sum of the iron and manganese in the Malayan ferberite exceeds that possible if the formula is (Fe, Mn)WO_4. Dana[8] suggested that ferberite did not exist as $FeWO_4$, but rather as a combination of $FeWO_4$ with FeO.

Crystallographic theory developed since Dana expressed his solution of the problem has demonstrated the impossibility of such a compound, and FeO has not been identified as a naturally occurring substance.

The latest edition of Dana[8] suggests instead: "The departure from (Mn, Fe): $W = 1$ shown by some analyses of ferberite and other members of the series apparently is due to analytical error." Although this is an easy explanation of composition difficulties, and although it is recognized that the accuracy of analyses of wolframite by the best procedures now known is always subject to question, it is believed that lack of agreement between the iron-plus-manganese content and the tungsten assay in various cases may be attributed to the presence of oxides of iron.

It is not proposed, of course, that these oxides are compounded with the wolframite in contradiction of crystallographic principles, but rather that there is an intimate mixture of wolframite, ilmenite, magnetite, and possible hematite crystals of submicroscopic size; there may also be other minerals in the mixture. The presence of titanium, as revealed by the spectrograph, indicates ilmenite, and both ilmenite and magnetite could be among the minerals removed by the Isodynamic separator during the cleaning process when it was operated at low magnetic intensity. The fact that strongly

magnetic minerals were present in larger sizes supports the contention that they could be locked in the supposedly pure wolframite samples used in this investigation and others.

The presence of hematite or one of its modifications was suggested by the gangue associated with the Nederland *A* ferberite, which had the general appearance of ferruginous chert under the microscope.

The relationship found between iron content and specific susceptibility in the wolframite family is shown in Fig. 3. The linear relationship between X^2 and the percentage of iron may be expressed by Eq. 13:

$$X^2 = 1347 - 13.1\ \text{Fe}. \qquad [13]$$

The correlation coefficient of the linear data is −0.762; the odds against a chance occurrence of such a correlation are greater than 500 to 1. It is recognized that this correlation and the equation are sensitive to small variations in the specific susceptibility and in the iron assay; they are presented to show that there is a dependence of susceptibility upon iron content and that the susceptibility decreases, rather than increases, with larger amounts of iron in the mineral.

The positions of the points for the Malayan and the unknown samples are worthy of comment. None of the x-ray patterns for these samples indicated the principal magnetite lattice spacing,* but a number gave indications of the secondary spacing. A particularly strong response from the Malayan sample suggested magnetite in the specimen. Since a percentage of magnetite too small to be detected by x-ray procedures could have a noticeable effect on susceptibility, it is considered that failure of this technique to give a positive indication of magnetite does not rule out its presence. The unknown specimen gave no unusual spacings in its x-ray pattern; the 6 pct Cu revealed by spectrographic analysis could have had a strong depressing effect on the susceptibility, as that element and its sulfides are theoretically diamagnetic.

Most significant is the fact that correlation of magnetic susceptibility with iron content is negative, and therefore positive with reference to manganese. Although manganese has the strongest response of the paramagnetic elements other than oxygen, it would not normally be expected to have a stronger effect than a ferromagnetic element such as iron. The explanation is to be found in studying the ionic susceptibilities of manganese and iron.

Iron in the metallic state is ferromagnetic, and thus its susceptibility varies with field strength. In the combined form, however, the ions have paramagnetic susceptibilities. The value for Fe^{+++} is the same as that for manganese, whereas for Fe^{++} it ranges from 89 to 94 pct of the amount for the ferric ion. Consequently when iron replaces manganese in the compound (Fe, Mn)WO_4, the net paramagnetic susceptibility is reduced.

When iron occurs with both valences in the same compound, as in magnetite, Fe_3O_4 or $Fe_2O_3 \cdot FeO$, or pyrrhotite, $Fe_{n-1}S_n$, the ion has a ferrimagnetic nature, and high susceptibilities that vary with field strength are observed.

* A spacing ranging from 2.46 to 2.497Å on the wolframite group may have concealed it.

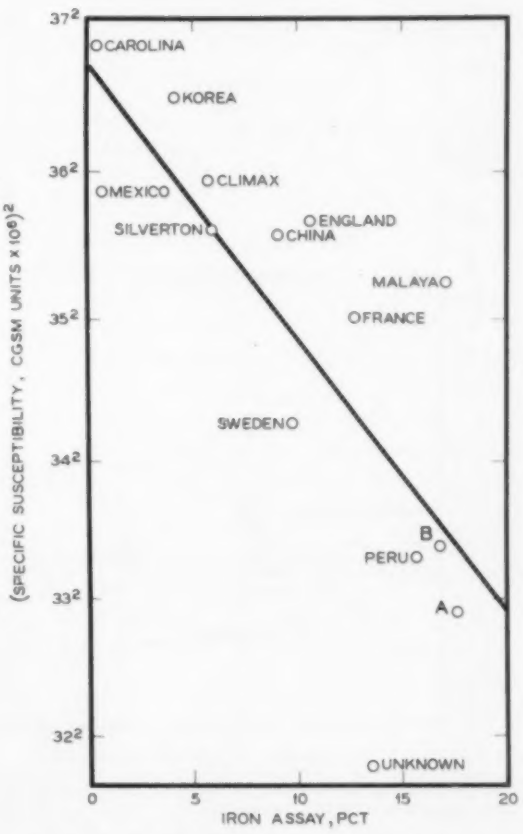

Fig. 3—Correlation of magnetic susceptibility with iron content in minerals of the wolframite group.

Sphalerites: Table II presents the data on sphalerite. It will be seen that each specimen has a different susceptibility for each field strength; this is due to the presence in the mineral of some substance that is either ferromagnetic or ferrimagnetic. The fact that iron is in the mineral, almost certainly in the form of a sulfide, is evidence that this characteristic is caused by the ferrimagnetic sulfide, pyrrhotite. The x-ray patterns of the various specimens did not differ significantly from each other with respect to the various sulfides of iron; however, only the Gilman sample contained enough iron for the sulfide to be detected by this technique.

Another noteworthy feature in Table II is that neither the susceptibility at a given field nor the rate of decline of that characteristic with increasing field strength is closely related to the iron content; the difference in rate of decline is strikingly indicated by the crossing lines in the bottom portion of Fig. 4.

The spectrographic record of higher nickel content in the Lockport sample is the most likely explanation of the greater slope, indicating stronger ferromagnetism, and the higher susceptibility at lower field strength, where ferromagnetism is more effective. It will be noted that the decline of the Lockport susceptibility places the values in a more normal relationship in fields greater than 19 kilo-oersteds.

The lower susceptibility of the Chester sample compared to the Bucks may be explained by the higher copper content of the Chester sample.

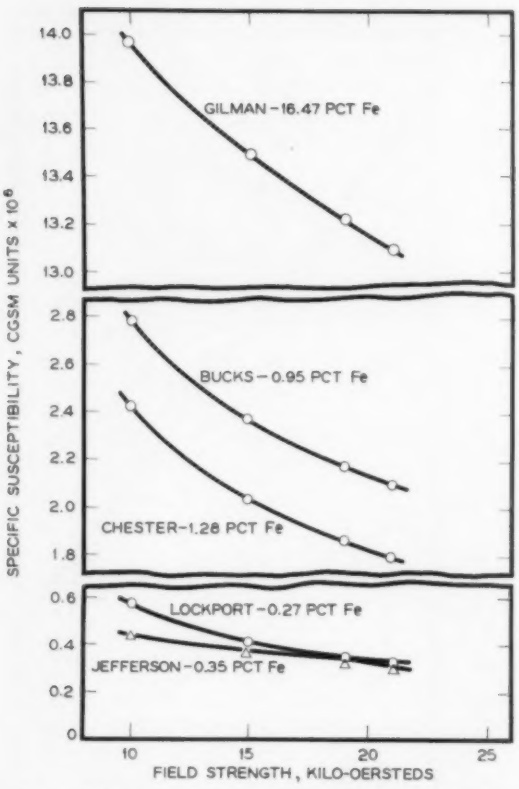
GILMAN – 16.47 PCT Fe
BUCKS – 0.95 PCT Fe
CHESTER – 1.28 PCT Fe
LOCKPORT – 0.27 PCT Fe
JEFFERSON – 0.35 PCT Fe
SPECIFIC SUSCEPTIBILITY, CGSM UNITS x 10⁶
FIELD STRENGTH, KILO-OERSTEDS

Fig. 4—Relationships between iron content, field strength, and magnetic susceptibility of sphalerite.

Correlation between iron content and magnetic response appears again to be parabolic, expressed at 10,000 oersteds by Eq. 14:

$$X^2 = 12.13\,Fe - 5.07 \qquad [14]$$

The correlation coefficient for the five values was +0.9995, with less than one chance in 1000 of fortuitous occurrence. In this case, of course, correlation is positive with respect to iron. It will be noted that susceptibility should be zero when the iron assay drops to 0.42 pct; the Lockport and Jefferson samples would be expected to have negative rather than positive values. More extensive investigation of this mineral should give a regression line intercepting the iron axis farther to the left.

The equation indicates that iron-free sphalerite should have a susceptibility of −2.57, which would not be possible. (Bismuth, the most diamagnetic of the solid elements, has a susceptibility of −1.35; the hydrogen has −1.97). The value of −0.264 for sphalerite reported by Voigt and Kinoshita[10] doubtless indicates the direction the line should take.

With the exceptions mentioned, the minor constituents or trace elements observed were not considered to have a significant effect upon the susceptibilities in either group of minerals.

Conclusions

The primary dependence of magnetic susceptibility upon iron-containing minerals was established, with the unexpected postulate that in minerals where iron in the ferrous state has a substitution relationship with manganese, there may be an inversion of the correlation of susceptibility with iron content. It was observed that susceptibility varied as the square root of the iron content, either directly, as in sphalerite, or inversely, as in wolframite.

The negative correlation of susceptibility with iron content in the wolframite series appears to be in direct conflict with a commonly accepted concept that the wolframite minerals are nonmagnetic with the exception of ferberite. This has been stated: "The high-iron members of the series are weakly magnetic."[9] Further conflict with this statement is found in Table I, which indicates a range in specific susceptibility of 31.7 to 36.8×10^{-6} cgsm units. This variation of some 15 pct between high and low values is hardly enough to justify a distinction between weakly magnetic and nonmagnetic members of the series, particularly when the nonuniformity of the magnets found in most laboratories is taken into consideration. It must be concluded that any ferberite that is unusually magnetic owes this property not to the high percentage of iron in the form of the tungstate, but to the presence of additional iron as magnetite, intimately locked with the ferberite so that it cannot be distinguished from the ferberite.

Because the concept that the ferberites are more highly magnetic is faulty, any attempt to improve

Table II. Magnetic Characteristics and Chemical Composition of Sphalerites, Susceptibility in Cgsm units x 10^6

Origin	Specific Susceptibility, H = 10,000	15,000	19,000	21,000	Volume Susceptibility, 10,000	15,000	19,000	21,000	Density	Chemical Analysis, Pct Zn	Fe	S
Gilman	13.962	13.493	13.220	13.068	56.71	54.81	53.70	53.16	4.062	42.05	16.47	33.75
Chester	2.4333	2.0438	1.8592	1.7912	9.960	8.365	7.610	7.331	4.093	63.15	1.28	32.18
Bucks	2.7809	2.3748	2.1748	2.0981	11.117	9.493	8.694	8.387	3.998	61.98	0.95	30.46
Jefferson	0.4508	0.3816	0.3499	0.3376	1.757	1.467	1.364	1.316	3.898	59.60	0.36	29.72
Lockport	0.5697	0.4120	0.3386	0.3130	2.314	1.673	1.375	1.271	4.062	61.19	0.27	31.13

Origin	Spectrographic Analysis, Pct* Co	Mn	Ni	Ag	Al	Ba	Ca	Cu	Mg	Pb	Si	Ti	W	Zr
Gilman	—	0.14	0.02	0.006	0.045	<0.02	0.15	0.3	0.06	0.5	—	0.02	3.5	0.012
Chester	0.013	—	0.035	0.004	0.02	0.03	0.15	2.	—	0.17	1.1	<0.002	—	<0.004
Bucks	<0.01	0.15	<0.007	—	0.065	—	0.3	0.018	0.18	0.5	3.	0.01	0.7	0.002
Jefferson	—	—	<0.001	0.0013	0.08	<0.02	0.4	0.019	0.35	0.025	1.	0.018	2.5	0.005
Lockport	—	—	<0.008	—	0.02	—	0.19	0.1	0.073	0.45	0.8	0.006	—	<0.001

Probable error is not indicated for the specific susceptibility of the sphalerite specimens because each value was based on only four observations.

* As, Be, Mo, Sb, Sn, and Sr were undetected. Cr (<0.003 pct) and V (<0.008 pct) were found only in the Gilman specimen.

grade and recovery of tungsten in this mineral by finer grinding to increase liberation of ferberite will probably give a magnetite concentrate and reject most of the tungsten with the types of concentrators now in use. Improvement should be sought by regrinding the present concentrates and removing the magnetite at low field intensity.

Since even the least magnetic of the wolframite samples was concentrated on the Isodynamic separator in the cleaning process, it is obvious that any mineral of this series which can be liberated from the accompanying gangue of low susceptibility without excessive grinding can be concentrated by a high intensity magnetic separator of proper design.

Sphalerite was found to possess the ferromagnetic characteristic of variation of susceptibility with field strength; from 10,000 to 21,000 oersteds that relationship was negative, with as much as 45 pct decline over that range. By contrast, the wolframites had susceptibilities more than twice that of the strongest sphalerite observed, with no ferromagnetic decline in strong fields.

The results indicate that the study of minerals now considered to have susceptibilities too low for magnetic separation should be continued, as present concepts may be erroneous. The study of minerals falling above and below this group in susceptibility should be carried out to give a complete picture of the magnetic properties of minerals.

Acknowledgment

This work was made possible by a fellowship grant of the National Science Foundation. It is reported in detail in a doctoral dissertation by Ernest Melvern Spokes entitled *The Relation of Magnetic Susceptibility to Composition in Minerals of the Wolframite Group and in Sphalerites*, The Pennsylvania State University, August 1956.

References

[1] L. G. Gouy: C. R. Academy of Science, Paris, 1889, vol. 109, p. 935.
[2] P. Pascal: C. R. Academy of Science, Paris, 1910, vol. 150, p. 1054.
[3] L. F. Bates: *Modern Magnetism*, 3rd ed., p. 115. Cambridge, 1951.
[4] S. Freed: *Journal of the American Chemical Society*, 1930, vol. 52, p. 2702.
[5] P. W. Selwood: *Journal of the American Chemical Society*, 1933, vol. 55, p. 3161.
[6] F. E. Hoare: *Proceedings of the Royal Society*, 1934, vol. 147, p. 88.
[7] J. D. Dana, et al.: *Manual of Mineralogy*, 16th ed., p. 311. John Wiley & Sons, New York, 1952.
[8] J. D. Dana, et al.: *The System of Mineralogy*, 6th ed., p. 985. John Wiley & Sons, New York, 1892.
[9] J. D. Dana, et al.: *The System of Mineralogy*, 7th ed., vol. 2, pp. 1066, 1067. John Wiley & Sons, New York, 1951.
[10] National Research Council of the U. S. A.: International Critical Tables, vol. 6, p. 364. McGraw-Hill Book Co., New York, 1929.

Discussion of this paper sent (2 copies) to AIME before April 30, 1958, will be published in MINING ENGINEERING.

Discussion

Genesis of Titaniferous Magnetites and Associated Rocks of the Lake Sanford District, New York

by J. L. Gillson

(*MINING ENGINEERING, March 1956; AIME Trans., vol. 205*)

Andre Hubaux: In the writer's opinion, more stress should be put on field and microscope observations, as J. L. Gillson does. His discovery of relics of big labradorite feldspars from the Marcy anorthosite in all the other rocks is proof enough that previous field observations have been inadequate.

The writer's field experience with anorthositic massifs is limited to the Egersund-Sogndal district in southern Norway; however, this is a very large and well exposed area. It seems to have so many points in common with the Adirondack region that a detailed comparison should be beneficial. This comparison was not possible 20 years ago, owing to the scarcity of geological data, at least for Norway. Both regions are now far better known—the Norway district because of the work of Professors Bugge and Barth[1-3] and especially because of the extensive field and microscopic research of P. Michot,[4-6] who introduced me in the field to the problems of that region.

In a particular unit of the Egersund district, a sodification of the plagioclase, very similar to what Gillson calls "andesinization," has taken place.[6] The percentage of anorthite in the plagioclase has dropped from 42 to 43 pct in the original norite down to 27 pct, but never below that level. This metasomatical transformation is a part of a whole series of processes of migmatitization which have produced, above the level of granitization, concentrations of Mg, Fe, and Ti and among them, patches and parallel bands of ilmenite and magnetite.

Thus both regions present somewhat comparable features and the theories to explain them have several points in common. However, as there seem to be differences between some American conceptions and the views commonly accepted at the University of Liege, I would like to make some comments about J. L. Gillson's article.

The author speaks of the garnet as being an antistress mineral. However, garnet may be found in schists, where its helicitic texture, when present, demonstrates its formation during differential movement. Furthermore, the whole concept of stress and anti-

stress minerals is no longer considered valid by European geologists, since it has been demonstrated that all supposed anti-stress minerals could be formed under nonhydrostatic pressure, and vice-versa.

The author describes and shows with photographs reaction rims of garnet which are "so characteristic of the gabbro and gabbroic ore" (p. 301) and which express a chemical disequilibrium between the feldspar and the ferromagnesian solutions responsible for the formation of these rocks. Later solutions formed the magnetite, ilmenite, etc., which are the ore minerals. But these minerals are presented as being later than the garnets. Must we then believe that these last solutions, in opposition to the first, did not react with the feldspar—that they were in chemical equilibrium with that mineral? This important difference between the activity of the first and last solutions is astonishing and should be explained.

Whatever hypothesis is put forward concerning these garnet reaction rims it should be noted that they do not exist in the Egersund district. There, many kinds of ores[47] are in contact with plagioclase, with which they seem to be in perfect chemical equilibrium.

All the problems dealing with anorthosite and related rocks are so difficult that as many observations as possible should be found to give us a hint concerning the origin of the different units. Along that line I suggest the following:

Among the norites and leuconorites of the Egersund district, some undoubtedly have a magmatic origin, whereas others, on the contrary, are formed by recrystallization in the solid state. P. Michot has demonstrated that the hypersthene in the magmatic norites has a *poikilitic interstitial texture*. The writer has found that in the same rocks the ilmenite[47] and the magnetite have the same texture. In such rocks, when they are examined in the field, the ferromagnesian minerals are evenly distributed and seem to have the same granularity as the plagioclase, and all minerals seem to have a diameter of about 1 mm. However, seen under the microscope, the grains of hypersthene, ilmenite, and magnetite are in fact much larger than those of the feldspar.

All the grains of one mineral have the same optical orientation within an area more than 2 cm in diam. This means that the grains of that mineral in this area belong to the same crystal that envelopes the plagioclases. This is readily seen for the hypersthene and the ilmenite, respectively in thin section and in polished section. When the nicols are crossed, and the stage is rotated, many *grains* of the mineral visible in the field show simultaneously the same color, since those *grains* all are parts of the same crystal. For the magnetite, one must rely on the parallelism of spinel and ilmenite grains formed by ex-solution to visualize the continuity of the crystals. Descriptively, this can be compared to big calcite crystals that are sometimes formed in sandstone, one individual of calcite enveloping and containing numerous grains and aggregates of sand. More correctly it can be compared with the ophitic texture, but it differs from it by the equidimensional aspect of the plagioclase and the very disseminated character of the enclosing mineral.

This is the poikilitic interstitial texture; it does not exist in norites and leuconorites which have recrystallized. In those rocks, on the contrary, the hypersthene, the ilmenite, and the magnetite are still interstitial, but they are much more equidimensional, and separated grains do not have the same orientation. Thus this aspect—this poikilitic interstitial texture—is very useful in the Egersund district to distinguish between norites of simple magmatic origin and norites in which recrystallization with or without introduction of new substances has taken place. It would be valuable to know whether this same criterion holds good for the rocks of the Adirondack region. If this is proved to be the case, then it could be used to identify the rocks that Gillson presents as meta-gabbro and distinguish them from those that other authors have called true gabbros of magmatic origin.

J. L. Gillson *(author's reply)*—Hubaux believes that he has developed diagnostic criteria for distinguishing recrystallized norites (or gabbro) from those of magmatic origin. Those rocks which are of magmatic origin have a poikilitic texture in which the hypersthenes, ilmenites, and magnetites are larger than the feldspars and include feldspar grains. No such observation was made in the Adirondack rock. If this texture is truly lacking, then the gabbros of the Adirondack are due to recrystallization as postulated in the original article. Obviously many observations of similar rocks must be made to establish the validity of this feature as a diagnostic one.

Hubaux also questions the conclusion that garnet is an anti-stress mineral. In the Adirondack rock the andesine grains show no strain, and the garnet which is later can be presumed to be an anti-stress mineral.

Garnet reaction rims are very characteristic of the Adirondack rocks and are not confined to the ilmenite-magnetite ores but are seen in some gabbros intrusive (?) into gneisses. Also admittedly they are not found in other anorthosite and gabbro rocks containing ilmenite-magnetite or ilmenite-hematite ores, like the deposits of the San Gabriel Mountains in California, at St. Urban, and at Allard Lake in Quebec. The garnet reaction rims indicate a period of unequilibrium that was characteristic of Adirondack conditions but was not a universal condition in rocks of this type. The reaction rims do, however, indicate recrystallization, and that was the point to be made.

Hubaux is to be commended for his additional information and observations in regard to these interesting rock types.

References

[33] T. F. W. Barth: The Large Pre-Cambrian Intrusive Bodies in the Southern Part of Norway. *International Geological Congress*, 1933, vol. 16, pp. 297-309.

[34] T. F. W. Barth: Litt om Sorlandets anorthositer. *Norsk geologisk tideskrift*, 1941, vol. 21, nos. 2 and 3, 1941, pp. 186-191.

[35] T. F. W. Barth: Geological map of the western Sorland. *Norsk geologisk tideskrift*, 1945, vol. 25, pp. 1-9.

[36] R. Michot: La série rubanée norite-granitique du massif anorthositique d'Egersund. *Annales de la Société Geologique de Belgique*, 1939, vol. 62, pp. 632-546.

[37] P. Michot: La couronne d'anorthosite hypersthenifère feuilletée et rubanée du massif anorthesitique d'Egersund. *Annales de la Société Geologique de Belgique*, vol. 62, pp. 547-551.

[38] P. Michot: Les anorthosites de la region d'Egersund. *Acad. Boy. de Belg. Bull. Classe des Sciences*, 1939, 5th ser., vol. 25, pp. 491-503.

[39] P. Michot: Le problème des textures dans les roches éruptives du massif anorthositique d'Egersund. *Ass. franc. p. avanc. des sciences, Liege*, 1939, pp. 524-528.

[40] P. Michot: Essai sur la geologie de la catazone (first note). *Acad. Roy. de Belg. Bull. Classe des Sciences*, 5th ser., 1951, vol. 37, pp. 260-276.

[41] P. Michot: Essai sur la geologie de la catazone (second note). *Acad. Boy. de Belg. Bull. Classe des Sciences*, 1952, 5th ser., vol. 38, pp. 495-500.

[42] P. Michot and J. Michot: Enclaves dans les anorthosites de la region d'Egersund. *Annales de la Société Geologique de Belgique*, 1953, vol. 76, pp. 239-247.

[43] P. Michot: Anorthosites et anorthosites. *Acad. Roy. de Belgique, Bull. Classe des Sciences*, 1955, 5th ser., vol. 41, pp. 275-294.

[44] P. Michot: L'anatexie leuconoritique. *Acad. Roy. de Belg. Bull. Classe des Sciences*, 1955, 5th ser., vol. 41, pp. 374-385.

[45] P. Michot: Structures tectoniques dans la catazone norvegienne. *Acad. Boy. de Belg. Bull. Classe des Sciences*, 1956, 5th ser., vol. 42, pp. 209-227.

[46] P. Michot: Les gisements de minerals noirs de la region d'Egersund. *Annales de la Société Geologique de Belgique*, 1956, vol. 79, pp. 183-202.

[47] A. Hubaux: Différents types de minerals noirs de la région d'Egersund. *Annales de la Société Geologique de Belgique*, 1956, vol. 79, pp. 203-215.

[48] J. Michot: Le phénomène magmatique au sein du massif anorthositique de Haaland, Egersund, Norvége. *Annales de la Société Geologique de Belgique*, 1955, vol. 78, pp. 247-266.

SME BULLETIN BOARD

Reports of Your Technical Society

Meet your officers

1958 Officers—page 383

1958 Directors—page 384

Plan now for Fall Meetings

Mid-America Minerals Conference

Rocky Mountain Minerals Conference

See page 385.

Rock in the Box ..... **page 387**

Miss some Preprints?

If you didn't get your **SME Preprints** at the Annual Meeting last month in New York, you are not out of luck. For a full listing and details of how you can order the papers you want, see page 398. A complete list of the papers and each ordering number is given.

Carlsbad goes TV ..... **page 391**

Pacific Southwest Mineral Industry Conference, Mar. 27-29

MBD Bylaws

The last line of the *Article III, Section 1,* was incorrect as it appeared in the January 1958 issue, page 115. This section should read: **"Section 1.** There shall be no dues for this Division but voluntary contributions may be solicited, subject to approval of the Society and AIME."

PROPOSAL FOR AIME MEMBERSHIP

I consider the following person to be qualified for membership and request that a membership kit be mailed to him:

Name of Prospective Member:

_____

Address

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_____

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Change of Address and Personals Form

To be sure that you receive your publications and correspondence promptly please fill in the form below and send it to **Society of Mining Engineers of AIME, 29 W. 39th St., New York 18, N.Y.:**

Name _____

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Personals: Please list below your former company and title and your new title and company (or new work) for use in MINING ENGINEERING. (Copy deadline for personals items is six weeks before date of issue.)

Former Company _____

Former Title _____ **Length of Time There** _____

New Company _____

New Title _____ **Date of Change** _____

Any recent activity that would be of interest to members:

_____

_____

Society of Mining Engineers President in 1958

Stanley D. Michaelson

STANLEY D. MICHAELSON, President of the Society in 1958, is a native New Yorker. He attended Lehigh University, receiving a B.S. degree in mining engineering in 1934, later doing graduate work there. Although he had done some prospecting in northern Ontario as a student, he began his formal career as a field engineer in the Mining Dept. of Bethlehem Steel Co. Mr. Michaelson was associated for six years with Allis-Chalmers Mfg. Co., first in the minerals research laboratories in Milwaukee, and later as metallurgical engineer and field engineer.

During World War II Mr. Michaelson served five years in the Army as lieutenant colonel in the Ordnance Department. Resuming his career after the war, he rejoined Allis-Chalmers as director of the Basic Industries Research Laboratories. In 1947 he joined Tennessee Coal & Iron Div. of U. S. Steel Corp. as a special engineer in the coal mines division. Subsequent promotions led to the position of chief engineer—coal mines and later, chief engineer—raw materials.

One of the highlights of his activity at TCD was the completion of the 20,000-tpd Concord mine project. Under his direction as chief engineer—coal mines this project marked the first integration of rock bolting in a mining scheme as a regular production tool, and the project also utilized the largest slope belt installed to that date.

In September 1954, Kennecott Copper Corp. announced Mr. Michaelson's assignment as chief engineer of the Western Mining Divs. with headquarters in Salt Lake City, a post he now holds.

An active AIME member, Mr. Michaelson served as Chairman of MBD in 1954, and in the same year was elected a Director of the Institute. Some of his technical articles were published in MINING TECHNOLOGY and dealt with ball and rod mill operations.

Society of Mining Engineers Officers in 1958

President-Elect

J. W. WOOMER

J. W. Woomer, President-Elect, will become President of the Society in 1959 at the Annual Meeting in San Francisco. Well known in mining and coal circles, Mr. Woomer is head of his own consulting firm, J. W. Woomer & Assoc.

A native of Philipsburg, Pa., he received a B.S. from Pennsylvania State University in 1925 and an E. M. in 1931. During his summer vacations he worked in the central Pennsylvania coal fields and later in Maryland. Mr. Woomer's earliest professional association was with the Pittsburgh Coal Co. and he was later active in the Ohio fields during a period with Hanna Coal Co. He formed his consulting firm in 1940.

Mr. Woomer's activities have taken him to almost all states in the U. S.; to Canada; many countries in South America and Europe; and to China, India, and Australia in the Far East. His professional work has been concerned with coal, lignite, clays, potash, copper, uranium, iron, oil, sands, and shales.

An active member of the SME Coal Division, Mr. Woomer had been serving as Chairman-Elect, taking office as Chairman of the Division in 1958. In addition to his AIME association, Mr. Woomer is a director of the Engineering Soc. of Western Pennsylvania and a member of Tau Beta Pi, honorary engineering society; Sigma Gamma Epsilon, mining society; and the Explorers Club of New York City; Pittsburgh Athletic Assn; and the University Club.

Past-President

E. A. JONES

Elmer A. Jones, now Past-President, was the first President of SME as established under the reorganization of AIME in 1957. He is manager of Southeast Missouri Div. for St. Joseph Lead Co. with headquarters in Bonne Terre, Mo.

Born in Minneapolis on Aug. 11, 1902, Mr. Jones attended public schools in his native city and graduated from the University of Minnesota School of Mines in 1924 with a degree in mining engineering. He began his career as an engineer with the Minnesota State Highway in 1924 and in 1925-1926 he worked for what is now part of Tennessee Copper Co. in Ducktown, Tenn.

Elmer Jones began his long affiliation with St. Joe in 1926. Before assuming his present post of division manager, he had served the company, successively, as mine surveyor, safety inspector, mine engineer, mine superintendent, and assistant general mine superintendent. During the years with St. Joe, Mr. Jones participated from the very inception of mine mechanization in the district. Two of his AIME publications have dealt this subject and he is considered an authority on trackless mining operations.

Besides his varied career in engineering and his contributions to the professional society, Elmer Jones has been active in civic affairs. In his hometown, Bonne Terre, he has served on the local school board, as well as filling the office of president for seven years. He has been a participant in such diversified groups as the Rotary Club, the Executive Council of Boy Scouts (St. Louis), Rivermines Engineers Club, and the Missouri Athletic Club.

(Continued on page 391)

SME Regional Vice Presidents in 1958

Eastern 1958-1961

C. E. LAWALL

Central 1957-1959

G. D. EMIGH

Western 1957-1960

J. D. FORRESTER

Know Your Society

Society of Mining Engineers Directors in 1958

These SME Directors took office at the Annual Meeting in February and will serve a three-year term ending in 1961.

Raymond B. Ladoo, in addition to being re-elected as a Director for a three-year term, has been renamed Society Treasurer. A well known consultant in the industrial minerals field, he is a native of Ayer, Mass., and maintains his headquarters in Newton near Boston.

A graduate of Harvard University with an A.B. degree and one in mining engineering, he began his professional career with two Virginia companies, Low Moor Iron Co. and John B. Guernsey & Co. Inc. His varied activities in the field particularly qualify Mr. Ladoo for his present consulting position. Among the companies and organizations with which he had been associated before beginning his present practice are U. S. Bureau of Mines, Colorado Fluorspar Corp., U. S. Gypsum Co., Organo Inc., Colonial Mica Corp., New Products Research Corp., Nieder Fused Quartz Co., and the War Production Board for which he was chief of the Mica-Graphite Branch.

Mr. Ladoo is the author of the book *Non-Metallic Minerals* as well as numerous technical articles and publications, ranging in scope from the economics of the nonmetallic mineral industries to treatises on such minerals as talc and fluorspar. His interests in the field have been AIME's gain, since he was one of the leading figures in the establishment of the Institute's Industrial Minerals Division in 1915 and has a distinguished record as one of its chairmen.

Brower Dellinger is assistant manager of the Tahawus operation, Titanium Div., National Lead Co. Inc.

A graduate of Stanford University with a degree in mining in 1936, he began his professional career with Newmont Mining Co. in the gold mines in Grass Valley, Calif. Prior to World War II, Mr. Dellinger served with Newmont, successively, in mining, timbering, and shift operations; as engineer; and engineer in charge of development. When the war broke out, he joined the U. S. Navy in the Construction Corps and terminated his service as a radar officer. He then rejoined Newmont as superintendent of the Esmeralda in Goldfield, Nev., later transferring to Grass Valley, Calif., as general superintendent, and then becoming assistant manager of all Newmont's gold properties.

Mr. Dellinger was associated for a time with the Coeur d'Alene Mining Div. of the Spokane-Idaho Mining Co. as general manager. He joined National Lead in 1954 as superintendent of exploration for the Mining Div. Prior to his transfer this year to Tahawus, N. Y., he was manager of the Monticello mill, Monticello, Utah, run for the government by National Lead.

"Truck" has had an active part in the publications work of MGGD (now Mining & Exploration Division) and has contributed, for a number of years, to the Annual Review section of MINING ENGINEERING, especially qualified to discuss underground mining.

Carl T. Hayden is vice president and general manager of Sahara Coal Co. Inc., Chicago. Born in Platteville, Wisc., in 1893, he graduated from Wisconsin School of Mines. His early professional experience was gained in the nonferrous industry, particularly zinc, during his service with Wisconsin Zinc Co. In 1920 he joined Madison Coal Corp. as division engineer and his career in coal has spanned more than 35 years.

Mr. Hayden began his association with AIME shortly after he switched his loyalties from zinc to coal. He has served as chairman of the Coal Division and a Director of AIME.

Norman L. Weiss is milling engineer for American Smelting and Refining Co., Salt Lake City.

A graduate of Massachusetts Institute of Technology with a B.S. and engineer of mines in 1923, Mr. Weiss was born in Boston in 1902. He did graduate work and research on heavy media cleaning at Pennsylvania State College. He had a varied career in beneficiation, the major portion of which has been Asarco. After college he was a research assistant for Milford Electrolytic Iron Co., Milford, Conn., before going to Penn State, where, in addition to his studies, he was a graduate assistant under Dean E. A. Holbrook.

Mr. Weiss began his years with Asarco in 1924 in El Paso, Texas, where his work as a metallurgist dealt with ore dressing problems on various Mexican ores. He traveled to Mexico in 1926, to Santa Barbara where he was metallurgist for Cia. Minera Asarco. Mr. Weiss' stay in Mexico and his stint for Cia. Minera Asarco lasted until 1945. His work as, successively, metallurgist, assistant mill superintendent, and mill superintendent dealt with complex research problems on ores handled by the subsidiary, and one result of his efforts was the development of an early method of Pb-Cu separation by flotation. During the period —1936-1945—when he was mill superintendent for two installations at

(Continued on page 387)

R. B. LADOO

W. W. SIMMONS

N. L. WEISS

Mid-America Minerals Conference to Convene In St. Louis in October

The AIME-sponsored Mid-America Minerals Conference will convene at the Chase Hotel, St. Louis, on October 23 to 25. Sponsored by the St. Louis Section, host, the meeting sessions will also take place at the Park Plaza Hotel.

A total of seven technical sessions have been tentatively planned, covering geology, mining, extractive metallurgy, coal, and topics of general interest to members of both the Society of Mining Engineers and The Metallurgical Society. Also scheduled is an iron symposium on the last day of the conference.

Two field trips have been arranged for Friday, October 24. Installations to be visited are Peabody Coal Co.'s River King strip mine and steel mill and St. Joseph Lead Co.'s Indian Creek mine and mill.

G. Donald Emigh, Monsanto Chemical Co., is general chairman for the conference. Some of his committee include: Gordon M. Bell, Alcoa Research Laboratories, and Ronald F. Lambert, American Smelting & Refining Co., finances and arrangements; Gill Montgomery, Minerva Oil Co., H. Leroy Scharon, Washington University, and H. R. Bianco, St. Joseph Lead Co., technical program; Joseph S. Quinn, Allis-Chalmers Mfg. Co., and V. W. Buys, Mine Safety Appliances Co., social arrangements and student activities; and Mrs. N. L. Shepard and Mrs. G. M. Bell, ladies' program.

Lost and Found

A folder of photographs, of which this is a sample, was turned over to the SME headquarters after one of the technical sessions during the recent AIME Annual Meeting, Feb. 17 to 20, in New York. Drop a line to the Editor, MINING ENGINEERING, if you can identify them.

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AIME NEWS

Abbreviations to Use

Fostered, no doubt, by Government agencies during World War II, this seems to be the *Age of Abbreviations* and AIME is no exception.

Many of the members and staff, particularly on the editorial side, have found that the use of abbreviations is a handy shortcut in an era of jets, missiles, and speed. Included as an official part of the Bylaws of the American Institute of Mining, Metallurgical, and Petroleum Engineers Inc. is *AIME* as the recognized abbreviation of the Institute name. In fact, the use of the initials (without periods and no spaces—AIME) is legal for checks or money orders. As a corollary, the Womens' Auxiliary of the Institute uses the term *WAAIME*.

The Society of Mining Engineers of AIME has long used initial abbreviations for the various divisions. *SME* designates the Society itself. The four divisions use: *MBD*, Minerals Beneficiation Division; *IndMD*, Industrial Minerals Division; and *M&ED* (temporary), Mining and Exploration Division. The Coal Division is, of course, *Coal*.

Lake Superior Mines Safety Council Will Convene in Duluth

The 34th annual conference of the Lake Superior Mines Safety Council will be held in Duluth, at the Hotel Duluth, May 22 and 23. Presiding officer for the conference will be A. J. Stromquist, director of safety, The Cleveland-Cliffs Iron Co., Council president.

Papers covering various phases of mine safety will be presented by representatives of the mining and allied industries.

The Lake Superior Mines Safety Council is composed of representatives of iron ore, copper, and limestone companies and from the U. S. Bureau of Mines.

Current officers of the Council are: S. B. Slade, Jones & Laughlin Steel Corp.; vice president; A. J. Windl, Oglebay Norton & Co., treasurer; and Allen D. Look, U. S. Bureau of Mines.

Next Rocky Mountain Meet in Salt Lake City

The 1958 Rocky Mountain Minerals Conference is scheduled for Salt Lake City, September 17 to 19. This fifth annual event is under the sponsorship of the Utah Section.

General chairman is A. J. Thuli, and he will be assisted by R. W. Lawson. Other committee chairmen are R. B. Mulchay, program; C. H. Henline, arrangements; N. L. McLeod, entertainment; W. S. Adamson, publicity; and Mrs. Ralph Tuck, ladies' events.

Information From EJC On Filing Income Tax

The following information has been received by Engineers Joint Council, and confirmed by their legal counsel as being correct:

> The Internal Revenue Service under ruling 55-4, I.R.B. 1955-1 states that a taxpayer "who gives his services gratuitously to an association, contributions to which are deductible" under the relevant provisions of the Code "and who incurs unreimbursed traveling expenses, including, the cost of meals and lodging, while away from home in connection with the affairs of the association and at its direction may deduct the amount of such unreimbursed expenses in computing his net income;" subject, however, to the limitation in respect to all gifts made to exempt organizations of our type; namely, that the total amount of such gifts made in any one year may not exceed 20 pct of the donor's gross income for such year. This limitation means that while such expenses are deductible, they are included with other gifts in computing the 20 pct limitation.

E N G I N E E R*

"EJC's Report on What's Happening in Engineering"

*A Periodic Newsletter from Engineers Joint Council • 29 W. 39th Street, New York 18, N. Y.

Look Ahead

From inaugural speech of EJC President Enoch R. Needles: ". . . The most productive future of EJC lies ahead. . . Its principles have gained the support of fifteen engineering organizations, representing some 250,000 individual engineers. This evidence of approval is truly and completely impressive. . . One of the finest conceivable developments has been the spirit of unanimous approval which appears undeniably evident in all of our societies toward our new United Engineering Center to be constructed adjacent to United Nations Plaza. . . The challenges before us in the coming year are without precedent. Of continuing interest is our endeavor toward complete unity in EJC on the part of all our major engineering organizations." (Mr. Needles comments on the international situation, quoted in press and radio, made these points:) "To ascribe the Russian rocket and satellite lead to weakness in American technology is misleading and erroneous . . . We have not lost our technological leadership or engineering productivity, but we must push everlastingly forward in our educational processes for engineers and scientists and in the orderly and intelligent administration of their endeavors and services . . . The first step the country must take is to provide adequate administration and direction for the technological team of scientists and engineers which exists. There is no reason why the U. S. cannot have, at one and the same time, a continuing rise in the living standard and a defense capacity of ever-increasing strength."

Upcoming Meeting

EJC Regional Meeting: First regional EJC meeting—scheduled for May 19 at Chicago's Sherman Hotel. Sponsored with cooperation of local sections of national societies and the Western Soc. of Engineers (EJC affiliate in area). Theme—*The Next Decade in Engineering.* Watch EJC Newsletter for program details.

International Relations

Chairman G. A. Hathaway of the Committee on International Relations, in a written report to the President of EJC, indicated extension of EJC's quest for unity in the engineering profession by assisting in organizing a Federation of Engineering Societies among nations of the Pacific and Far East. Such a federation, of which EJC would be a member, tentatively includes United Technological Organization (Philippines), Inst. of Engineers (India), Japanese Federation of Engineering Socs., Inst. of Engineers (Pakistan), Inst. of Engineers (Australia), Council of New Zealand Inst. of Engineers, and Assn. of Engineers (Burma). These recommendations by EJC's CIR antedates federal intent in this area and on Jan. 9, 1958, this CIR recommendation was approved by EJC's Board:

> "believing that the furtherance of world peace depends upon the cooperation of professional groups of all countries, it is recommended that EJC confirm its interest by requesting the Committee on International Relations to make a further unofficial survey upon which to base a definite recommendation on the formation of a Federation of Engineering Societies of the Pacific and Far East areas"

Watch For

• EJC Policy Statements on education for national security and—at least equally important—policy recommendations to end gross misuse of engineering manpower through outmoded government manpower policies.

N. M. Lazar Represents AIME at Recent ASME Symposium in Detroit

Nicholas M. Lazar was the official AIME representative to the Accreditation Symposium sponsored by ASME in Detroit on Nov. 7 and 8, 1957. Mr. Lazar represented President Holt and the Institute at the Symposium, purpose of which was to disseminate more widely information relating to the accrediting methods of ECPD and particularly to stimulate awareness of the responsibilities of technical society members in this concern.

Upon his return from the meeting, Mr. Lazar reported on the Symposium and his reactions as a delegate. His summary follows.

> "The purpose of this seminar was to acquaint people in industry with the problem of engineering accreditation and to get them interested in serving on accreditation committees. J. H. Davis, President of Stevens Institute of Technology gave the introductory remarks. He discussed the problems in mechanical engineering education. Necessarily the basic engineering education is a compromise between quantitative and qualitative factors and standards. There is also a question of how long the program should last—four, five, or six years. How practical the education is to be—should it be for design, development, research, or some other aspect?
>
> "In view of the rapid technological progress, should education change more rapidly? In the present engineering curricula, as a result of outside pressures, a great deal of time is given to non-technical subjects. Should this trend continue, and if so, where will the technical subjects be taught?
>
> "The general philosophy of the accrediting program is to avoid the setting of minimum standards, and not put engineering education into a straight jacket. The individual curricula and not the college or university is accredited. The accreditation is done on the basis of periodic visits by a committee composed of qualified individuals. The committee has no definite check list upon which to base their decisions. The judgement of the committee is based on the qualitative information obtained from the faculty and on quantitive data furnished by the administrative of the institution. The accreditation committees encourage experimentation in teaching and curricula.
>
> "Professors Newman Hall and R. G. Folsom presented a skit to illustrate mechanics and problems involved in accreditation. It was apparent that considerable thought and deliberation went into the committee's work. There are many facets of teaching and administration which the committee investigates.
>
> "It was demonstrated how the committee obtains its information and what it is looking for. It is not officially stated, but they rate the curriculum on the qualifications of the faculty. From the interviews with the faculty, the examination of course content, student papers, and examination papers, it is judged what the faculty wants to accomplish and what it accomplishes with the student.
>
> "My impression of the seminar was that it was a worthwhile attempt. It aroused considerable interest by people in industry in engineering accreditation. Of the 68 in attendance, about two thirds were from industry and the remainder from educational institutions."

ROCK IN THE BOX

Mining & Exploration Division

By the time this appears in print our Annual Meeting will have been held and your new officers will be busy with their new duties.

To those of you, who have had no experience in attempting to make and keep a good organization goirg in our Division, let it be known that it is no easy matter. Many hours must be spent in planning, correspondence, reviewing papers, and in meetings, before programs can be presented or papers published or awards made.

These hours have been spent by our outgoing officers and committeemen during the past year not only in keeping the old MGGD going, but in reorganizing into the new Mining and Exploration Division. The time spent was not for personal gain or glory, but strictly a contribution to the Division, the Society of Mining Engineers, and AIME.

Let us all give our vote of thanks to the outgoing officers and committee members for a job well done.

This year it is hoped that the Division will go forward to even better things as the Mining and Exploration Division. The new name and Bylaws were established to get the most for all from the combined efforts of all Division members.

You have approved this reorganization by your votes (or should it be said "lack of opposition votes"). In either case, it is your Division and will work only as well as you help it to work.

In making plans for reorganization many patterns and methods were probably considered. The final Bylaws were apparently based mainly on two outstanding examples of AIME activities, the Minerals Beneficiation Division and the Arizona Section.

The Unit Committee idea is a direct steal from MBD, where it has worked very successfully. This was backed up by experience in the Arizona Section, which, under the leadership of C. R. Kuzell, was really rejuvinated when a similar system was applied to it.

The key men in the new set-up appear to be the Unit Committee Chairmen. There is one for each—Open Pit Mining, Underground Mining, Geology, Geophysics, and Geochemistry.

The work of these Unit Committee Chairmen can be made easier, and the interests of the Division and AIME be aided, if you will contact the chairman of the committee in the field of your interests. Give him your ideas. Make a sincere offer to help and then carry through on your offer. Timely papers on items of interest, suggestions for programs, and constructive criticism should all be welcomed.

It is rumored that *Rock-in-the-Box* will have a regular editor. This avenue will also give you a chance to express your views.

All in all, let us get together and show MBD that, although we had to copy their ideas, we can make the ideas work better than the originators of the idea.

Your slate of officers as presented by the Nominating Committee were as follows:

Chairman	H. C. Weed
Assistant Chairman	Lyman H. Hart
Vice Chairmen	John G. Hall (Publications)
	Robert J. Lacy (Program)
	Herbert E. Hawkes, Jr. (Membership)

You may expect a full list of the unit committee chairmen, and others in an early issue of MINING ENGINEERING, if the editor is on his toes.

* * *

NOTE: This issue of *Rock in the Box* was contributed by an anonymous writer. It is suspected that he is either an MBDer, turned Miner and Explorer, or a member of the Arizona Section, perhaps both.

Signed:

The Editor
MINING ENGINEERING

SME Directors in 1958

(Continued from page 384)

Santa Barbara and consultant for other Asarco mills in Mexico, the number of accidents and labor cases there were reduced to a record low.

After a brief spell as metallurgist for Dow Chemical Co. in San Francisco, Mr. Weiss returned to Asarco in Salt Lake City as milling engineer in 1948. He has supervised company mills in the U. S. and abroad, done consulting work for other concerns, assisted in improvements at existing mills, and been involved in planning and construction of numerous new installations.

Since joining AIME, Mr. Weiss has been active on the Local Section scene and a loyal member of MBD. He has served on almost every Division committee—concentration unit process, operating controls, membership, symposium, Richards Award, papers and publications, and program. As an officer of the Division, Mr. Weiss served as regional vice chairman, associate chairman, and chairman in 1956. He has been active in SME, represented AIME at international meetings, and assisted with regional meeting. A contributor to the beneficiation literature, his first AIME contribution was published in 1930.

W. W. Simmons is chief geologist for Miami Copper Co., Miami, Ariz.

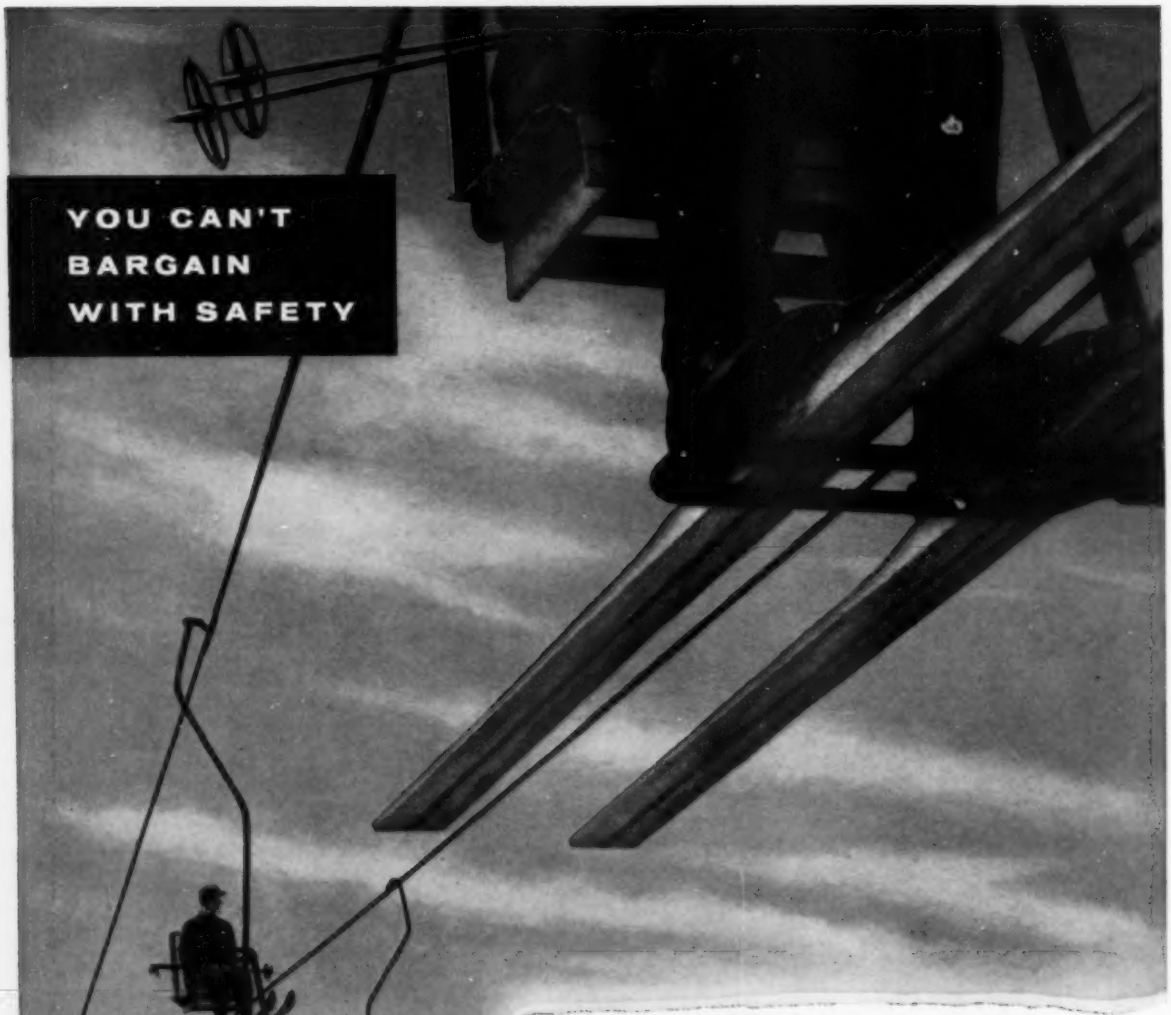
A native of Birmingham, he graduated from Birmingham-Southern College with a B.S. in 1933. Before entering the graduate school at the University of Arizona where he earned an M.S. in 1938, Mr. Simmons worked as an assayer for Hog Mountain Gold Mining and Milling Co., Alexander City, Ala., and as a rodman for the USGS in the southwestern piedmont. In 1938 he joined Tennessee Copper Co., Ducktown, Tenn., where he was junior geologist, mine engineer, geologist, and chief geologist, respectively. In 1953 Mr. Simmons went to Miami Copper.

Active while in Tennessee on various committees of the Southeast Section, he continued his AIME activities with the Arizona Section.

Incumbent Directors

The following SME Directors, installed in 1957, are serving a two-year term expiring in 1959: Gill Montgomery, M&ED; Sherwin F. Kelly, M&ED; C. T. Holland, Coal; E. H. Crabtree, Jr., MBD; and T. L. Kesler, IndMD.

Directors who took office in 1957 for a three-year term to expire in 1960 are: H. C. Weed, M&ED; A. E. Weissenborn, M&ED; J. W. Woomer, Coal; R. M. Grogan, IndMD; and D. W. Scott, MBD.



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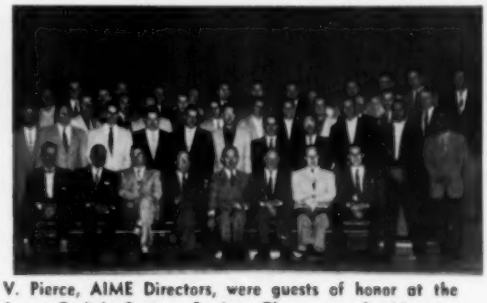
Around the Sections



F. W. Strandburg and Roger V. Pierce, AIME Directors, were guests of honor at the January 9 meeting of the Anderson-Carlisle Society, Student Chapter at the Montana School of Mines. Mr. Pierce, left, was the principal speaker. Shown, right, are visitors and faculty who attended.

• The **Anderson-Carlisle Society,** Student Chapter at Montana School of Mines, met on January 9. Guests of honor were Fred Strandburg of Butte and Roger Pierce of Salt Lake City, Directors of AIME. Mr. Pierce was major speaker of the evening and his subject—*The Minerals Engineer and What's Next.*

• The annual Anaconda joint meeting of the **Montana Section** and the Montana Soc. of Engineers was held in the Montana Hotel, Anaconda, on February 8. Wesley C. Funk, chief research engineer with the AEC, discussed *Recent Developments at the National Reactor Testing Station, Arco, Idaho.* His talk was preceded by a social hour and prime ribs dinner.

• The **Colorado MBD Subsection** held its annual breakfast on February 8 in the Club Room of the Cosmopolitan Hotel, Denver. The breakfast was held during the Colorado Mining Assn. meetings.

• The November 21 dinner meeting of the **Colorado Section** was held at the University Club, Denver. Robert C. Campbell, survey engineer with the Eastman Oil Well Survey Co., was the guest speaker and his topic was *Directional Drilling.* He showed and discussed the various instruments used in this work.

The December 19 meeting was a joint program-business one. First order of business was the election of the following new Section officers: Truman H. Kuhn, Section chairman; William L. Miles, Jr., vice chairman; and Arthur Hill, secretary-treasurer. The following directors were chosen: Asher H. Patten, immediate past-chairman; T. C. Heistand, Petroleum Section; and Al G. Hoyl and R. W. Graver, Denver area. Presented during the meeting was the Viola Vesta Coulter scholarship award to Thomas B. Waters, geology student at the Colorado School of Mines. John W. Vanderwilt presided and Mr. Coulter presented the award. Mr. Wayne Hazen, guest speaker of the evening, discussed the metallurgy of uranium ores of the Ambrosia Lake area and his talk was illustrated by slides. Final event of the evening was a motion picture showing work at the research facilities of the Kerr McGee Oil Co. near Golden.

The first meeting of the new year was held on January 16 at the University Club. Program subject was *Use of Plastics in Process Equipment* and the featured speaker was John B. Mackenzie, Jr., sales manager for Haveg Corp., Wilmington, Del., who was assisted by P. L. McWhorter, also from Wilmington, and Joe Coffman, the company's Los Angeles sales representative. Mr. Mackenzie briefly traced the history of his company and reviewed the application and limitations of thermosetting and thermoplastic resins. The various points made were illustrated by a sound movie which showed scenes from the factory and revealed manufacturing methods as well as examples of installed tanks, stacks, heat exchangers, piping, and other equipment.

• John C. Kinnear, Jr., President of The Metallurgical Society of AIME and general manager, Nevada Mines Div., Kennecott Copper Corp., was the featured speaker at the December 13 meeting of the **Nevada Section** held at the Fremont Hotel, Las Vegas. Mr. Kinnear's subject was copper mining in White Pine County, Nevada, and he discussed the life and activities of the people in the area, showing slides of winter and summer sports, water supply, mountain ranges, and roads. He announced that a huge skip haulage system which will cost approximately $1,500,000 is being installed by Kennecott at Liberty Pit. He made this announcement to illustrate his convictions that mining in Nevada is not only not dead but will continue to be an important factor in the State's economy.

James Wilson of Reno, a geologist for The Anaconda Co., is in charge of the Section's student prize paper contest for 1958. The contest, which is open to undergraduate students enrolled at the MacKay School of Mines, University of Nevada, is for papers on some subject in the general industry field and closes on March 15. Professor Joseph Lintz, Jr., is the MacKay School of Mines faculty advisor for the Crucible Club, student society of AIME at the university. Last year's contest winners were Lewis Lohr, first prize, and Max Botz, second.

• The **San Francisco Section** held its annual reminiscence meeting and Christmas party on December 11 at the Engineer's Club. The evening's proceedings began with cocktails, roast beef dinner, and a floor show. George Trescher was head of arrangements for the entertainment and Bill Marcum put on the show which was headlined by Bob Haskell as master of ceremonies and Rod McCauley furnishing the piano accompaniment. Other Section members pitched in to make the show a success.

William T. Griswold, II, was principal speaker at the January 8 meeting. Mr. Griswold, who is manager of the Minerals Dept., Kern Land Co., spoke on the *Exploration and Development of the Pima Mine,* tracing the various phases of exploration and development until the property was brought to production. His talk was illustrated with color slides.

• New officers of the **Lehigh Valley Section** were elected on December 6. They are: Mark S. Childs, chairman; Nathan M. Brown, vice chairman; Robert Sleeman, second vice chairman; Henry J. Burnell, third vice chairman; Robert M. Johnson, manager for three years; Daniel S. Lyons, manager for two years; and Charles J. Tebelman, manager for one year. The principal speaker at the meeting in the Lehigh Valley Club, Allentown, was Grover J. Holt, President of AIME and general manager of the Cleveland-Cliffs Iron Co. Mr. Holt discussed the unlimited reserves of low grade iron ore in the U. S. and stressed the need for plants to process this supply. Ernest O. Kirkendall, AIME Secretary, discussed Institute affairs.

• The **Ajo Subsection,** Arizona Section, met on December 12 in the Recreation Hall, Ajo. This was a joint meeting with the WAAIME and the evening was devoted to cocktails, dinner, and dancing.

At the January 9 meeting in the Copper Coffee Shop, Ajo, three members who are from the New Cornelia Branch, Phelps Dodge

(*Continued on page 390*)

New Upper Peninsula Section officers were elected at a recent meeting in Ishpeming, Mich. Shown with Grover J. Holt, AIME President, are, left to right, Victor E. Kral, John C. Wangaard, Mr. Holt, and Roy W. Drier.

Corp., reported on the Arizona meeting held in Tucson on December 2. R. E. Rhodes reported on open pit mining, labor relations, and a comparison of the scientific and technical education of U. S. and Russia. Jack Wyatt, who also stressed the need for more scientific and technical education in the U. S., reported on preconvention activities and the segregation-process of mineral dressing. Forrest Rickard talked on waste heat boilers in reverberatory furnaces in copper smelters and their functions.

• The **Yavapai Subsection,** Arizona Section, holds monthly cocktail hour-dinner meetings. No meeting was held in December due to a conflicting date with the State Section meeting in Tucson, but at the meeting on January 7, J. David Lowell of Pan American Ventures gave a talk on the occurrence of uranium in diatremes in the Hopi Buttes area of northern Arizona. His talk was illustrated with slides.

At the January meeting the following Subsection officers for 1958 were elected: Arthur R. Still, chairman; Fred Gibbs, vice chairman; and A. W. Jeffers, secretary-treasurer.

• The **Smelting Division** of the **Arizona Section** met on December 2 at the Pioneer Hotel in Tucson. R. C. Wilson, San Manuel Copper Corp., presided and introduced F. J. Christensen, Stearns-Roger Manufacturing Co., who presented a paper on waste heat boiler design for reverberatory furnaces. He discussed designed features of the newest installations and showed slides to illustrate his points. Also included on the program was a showing of *Mining and Smelting of the Sudbury Nickel Ores,* a film produced by the International Nickel Co. The Smelting Division joined other technical divisions in the evening for cocktails, dinner, and dancing.

• The **Spokane Subsection** of the Columbia Section held a joint meeting with the Inland Empire Section of the American Chemical Soc. on November 21 at Knud's Copper Grill, Spokane. Featured speaker was H. F. Walton, of the University of Colorado, whose subject was *Uranium Geochemistry.* Dr. Walton pointed out that this country's major uranium deposits evidently have been leached from masses of granite or rock rich in volcanic ash. The uranium so leached has been redeposited in more concentrated form by precipitation from watery solutions. Field studies make it almost certain that the deposition of uranium from ground water has involved reduction of uranium by decaying vegetation or asphaltic material and once deposited the uranium can be reoxidized to give the familiar yellow ores. Illustrating his talk with slides, he went on to discuss other means whereby uranium has deposited and showed the Gas Hills area of Wyoming where uranium deposits have been washed from granite hills and precipitated on the shores of an ancient shallow inland sea. Dr. Walton also spoke on other deposits such as the Ambrosia Lake uranium field in Mexico and the Spokane Indian reservation find.

• E. C. Stephens, chairman of the Spokane Subsection, has been elected chairman of the **Columbia Section.** Other Section officers are: C. E. Milner, secretary-elect; Rollin Farmin, vice chairman and head of the Coeur d'Alene Subsection; and Sam Barton, vice chairman in charge of the Snake River Subsection.

• At the December 20 meeting of the **Oregon Section** held in the Burns Restaurant, Portland, William T. Kay, vice president and general sales manager of E. J. Bartells Co., discussed *Geological Formation and History of Missouri Fireclay Fields.* A film was shown on refractories—*Master of Fire, Servant of Industry.*

E. C. Babson, AIME Vice President, was the featured speaker at the January 17 meeting. He talked on the type of oil fields and their development in the Calgary, Albe., oil district of Canada.

• New officers of the **Eastern North Carolina Subsection** were elected at the December 14 meeting. They are: A. M. Szynklewski, chairman; Harry E. LeGrand, vice chairman; and Phipps A. Hager, secretary-treasurer.

• Re-elected officers of the **Upper Peninsula Section** are: chairman, Victor E. Kral, resident manager of Northern Mining Section, Ford Motor Co.; vice chairman, John C. Wangaard, superintendent of the Cory Mine, Pickands Mather Co.; and secretary-treasurer, Roy W. Drier, professor, Michigan College of Mining and Technology.

• Hubert E. Risser, mineral economist from Illinois Geological Survey, addressed the February meeting of the **Chicago Section,** held at Chicago Bar Assn. Dr. Risser reported to Section members on the results of his study of metallurgical coke from Illinois coal. The future of the Chicago area as steel producing center can be greatly affected by the ability to solve technical and economic problems in obtaining metallurgical coke from the coal. Technical chairman for the Section meeting was Harold Jackman, chemical engineer, Illinois Geological Survey.

• The **Mineral Industry Group** has been formed as the third subgroup of the **Pittsburgh Section.** Meeting on January 16 at the Gateway Plaza, Pittsburgh, the group elected the following officers: K. F. Peterson, honorary chairman; Herbert A. Franke, chairman; R. D. Thompson and J. V. Melvin, vice chairman; R. E. Lund, secretary-treasurer; and C. H. Schweinsberg, extra member of the executive committee. The new Mineral Industry Group embraces as its aims and activities coverage in the fields of extractive metallurgy, nonferrous and industrial minerals, minerals beneficiation, mineral economics, geology, mining, and other general topics of interest to the minerals industry. Featured speaker at the meeting was Dennis J. Carney, division superintendent, Steel Production, Duquesne Works, U.S. Steel Corp. Dr. Carney, who was a member of a ten-man exchange team between New York University and the Moscow Steel Institute which spent three weeks examining the Russian steel industry and observing its technical education system, spoke on *Observations on Russian Steel Industry, and Technical Education.*

• Grover J. Holt, AIME President and general manager of the Cleveland-Cliffs Iron Co., was the guest speaker at the December 11 meeting of the **New York Section,** held at the Mining Club, New York. Mr. Holt discussed Institute affairs with emphasis on the effects of the reorganization, and also touched briefly on new developments in the iron ore beneficiation industry.

At the January 16 meeting in the

(*Continued on page 394*)

AIME Carlsbad Potash Section Produces TV Education Series

The Carlsbad Potash Section has been active in sponsoring a continuing program aimed at interesting young people in careers in science and engineering. As part of this program, the Section recently completed the showing of a series of ten ½-hr educational television programs over Carlsbad KAVE-TV.

The programs, presented by the Section with the cooperation of International Minerals and Chemical Corp. and the Carlsbad City schools, were based on a filmed series entitled *The Elements*, featuring Nobel Laureate Glenn T. Seaborg. The series was produced at the University of California by Dr. Seaborg and his staff and is designed to raise the level of public knowledge and understanding of chemistry and its role in modern life. In addition to Dr. Seaborg, a number of other distinguished scientists appeared in the ten films. Working with the highly technical equipment of the University of California radiation laboratory, Dr. Seaborg explained what an element is, how elements combine in compounds, how the 11 synthetic elements were predicted and made, and how elements are distributed in the earth and universe. In the films, he also discussed the history of chemistry, touching upon ancient chemistry and alchemy (concentrated upon the efforts to make gold), the Greeks' unproved concept of the atom, and the isolation of the first elements.

Each of the ten films was an entity, covering one aspect of chemistry. The first, shown on October 19, was *Building Blocks*, a general introductory to the series and sparking the theme—the urgent need for trained scientists in America today. *Atoms Into Molecules* continued the explanation of the basic aspects of chemistry. The third and fourth films took the viewer back in time—*From Alchemy to Chemistry* traced the historical development of the subject and *The Missing Elements*, concentrating on instruments and modern discoveries, brought the story back to present times.

Some applications and recent advances were covered in *Putting Elements to Work*, chemistry in blast furnaces and oil refineries; *Modern Alchemy*, synthetic elements and the use of the cyclotron; *Beyond Uranium*, exploring atomic energy; and *Making Elements*, the synthesis, isolation, and identification of Mendeleevium.

The ninth and tenth films took chemistry to the earth and beyond. The *Planet Earth* explained the makeup of the earth, processes by which elements combine to form living things, and the composition of man himself. *The Universe*, presented on December 21, explored the realms of outer space.

C. E. Pressnell, Carlsbad Potash Section chairman, right, and E. C. Skinner, manager, International Minerals and Chemical Corp., look over one of the ten educational films shown by the Section recently over the Carlsbad, N. M., television station KAVE-TV. International Minerals & Chemical helped underwrite the cost of the series.

The Carlsbad Potash Section hopes, by bringing this series of programs to viewers in the area, to have created a better understanding of chemistry and its importance in everyday life. Section members hope that, by being among the pioneers sponsoring such a program, others may follow the lead given. Based upon the enthusiastic response of its members, educators, and members of the community, the Carlsbad Potash Section is going ahead with plans to present similar programs in the future.

Section officers for 1958 are: C. E. Pressnell, chairman; Jerry Tong, first vice chairman; George R. Bowland, second vice chairman; and Ralph E. Littrell, secretary-treasurer.

SME Officers in 1958

(Continued from page 383)

Charles E. Lawall is Eastern Regional Vice President and is serving a three-year term which will expire in 1961. He is vice president of the Chesapeake & Ohio Railway Co.

A graduate of Lehigh University with E.M., M.S., and honorary LL.D degrees, he was born in Catasauqua, Pa., in 1891. Dr. Lawall began his professional career as a testing engineer in the Pittsburgh Testing Laboratory. He then served as chemist for The New Jersey Zinc Co.; mining engineer for Peal, Peacock & Kerr; in the Metallurgy Dept., General Motors Corp.; and as mining engineer and later research engineer for Bethlehem Steel Co.

In 1921 Dr. Lawall entered the educational field, first as an instructor in the Geology Dept., Lehigh University, and then as assistant professor at the West Virginia School of Mines. He served as professor and director at the School until 1938 when he was made acting president of West Virginia University. Almost immediately thereafter he became president of the University, a position he held until 1945 when he became engineer of coal properties for the Chesapeake & Ohio Railway Co., rising, successively, to assistant to the vice president, the office he now holds.

Dr. Lawall has been a member of AIME since 1914. He was chairman of the Coal Division in 1940 and a Director of AIME from 1951 to 1953. His contributions to the coal industry and his publications on education earned him the Bituminous Coal Research Award in 1957. Dr. Lawall was honored at the recent Annual Meeting when he was recipient of the second MIED Award.

G. Donald Emigh, Central Regional Vice President, was chosen in 1957 by the new Society to serve a two-year term which expires in 1959. He is director of mining for the Inorganic Mining Div. of Monsanto Chemical Co., with headquarters

(Continued on page 395)

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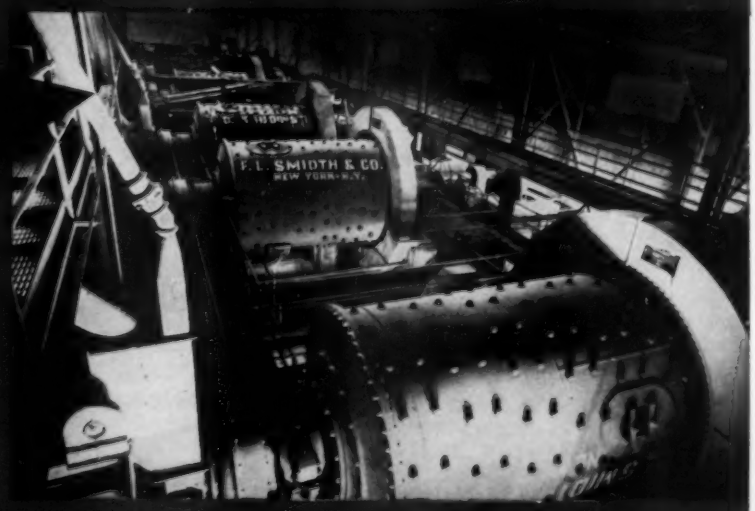

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PERSONALS

Robert H. Weeks, Jr., has been appointed assistant division manager for the Edison Storage Battery Div., Thomas A. Edison Industries, McGraw-Edison Co.

R. H. WEEKS, JR.

The following promotions were announced by Chile Exploration Co., subsidiary of The Anaconda Co: **Joseph C. Allen,** general superintendent of plants; **David S. Sanders,** assistant general superintendent of plants; **Charles M. Lagergren,** concentrator superintendent; **Francis E. Jones.** assistant to the concentrator superintendent; and **Peter B. Hobsbawn,** concentrator general foreman.

Robert T. Banks, formerly sales engineer for C. F. Braun and Co., is presently with Vitro Engineering Co. as assistant sales manager.

Phillip P. Powers, formerly mining engineer and shift boss at the Andes Copper Mining Co., is now chief mine engineer for the Dulaney Mining Co., Grand Junction, Colo.

Kenneth C. Brownell, chairman of American Smelting & Refining Co. has been elected a director of the Federal Insurance Co.

Russell G. Haworth was elected president of the New Mexico Mining Assn. He is vice president, Potash Co. of America.

The following appointments were announced by U. S. Smelting Refining and Mining Co: **Benton Boyd,** formerly superintendent, became manager of the U. S. and Lark Mine; and **Max M. DuBois,** who had been assistant to the manager of mines, became assistant to the vice president and general manager of western operations.

K. L. Allen has been appointed assistant superintendent of mining at Cerro de Pasco Corp., Morococha, Peru.

Fred L. Humphrey is on two years leave from Stanford University and has gone to the University of Bahia, Brazil, where he has established the first school of geology in Brazil.

C. D. RAMSDEN

C. D. Ramsden has been named president and general manager of the Pacific Coast Engineering Co., Alameda, Calif.

L. W. Hauschild, formerly aeronautical research scientist with the U. S. Air Force, is now computer for Geophysical Service Inc., Dallas.

Lane Mitchell, Georgia Institute of Technology, and **Wayne Deringer** of A. O. Smith Corp., have been appointed by John F. McMahon, president, American Ceramic Soc., to represent the Society on the Special Committee on Manpower for the Metallurgy and Ceramics Professions, sponsored by the Society, AIME, and ASM.

H. Marks, formerly working as a private consulting engineer, is now manager, Brisbane Branch, R. B. M. Long Pty. Ltd., Brisbane, Australia.

George C. Lipsey has resigned as vice president and general manager of Britannia Mining & Smelting Co. Ltd., and is taking up residence in Vancouver. He had been with the company since 1924.

Douglas R. Mabey, formerly in the Engineering Dept. at Kennecott's Western Mining Div. has been appointed contract engineer for the Utah Copper Div., Kennecott Copper Corp.

The following changes have taken place in the executive personnel of The Anaconda Co. and its subsidiaries: **Richard S. Newlin,** vice president in charge of mining operations since 1952, has been promoted to the position of vice president in charge of operations; **Thomas A. Campbell,** vice president of Anaconda since 1956, has been elected to the newly created post of vice president-Latin-American affairs; and **Charles M. Brinckerhoff** has been elected executive vice president of Andes Copper Mining and Chile Exploration Co.

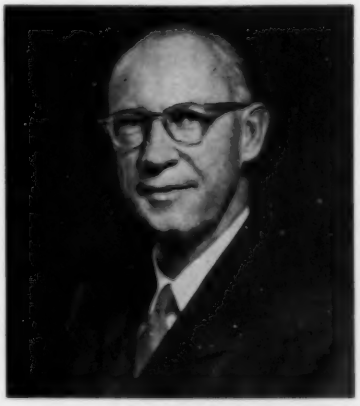
Paul P. Schapiro, previously night foreman of the Banner Mining Co., Tucson, Ariz., is presently mining health and safety engineer for the U. S. Bureau of Mines, Denver.

Maurice Baker, formerly pit engineer at Consolidated Coppermines, is now production assistant for the Baroid Corp., Houston.

Lockwood W. Ferris, formerly vice president and general manager of Bonneville Ltd., has been named president and general manager.

(*Continued on page 396*)

R. S. NEWLIN



T. A. CAMPBELL

C. M. BRINCKERHOFF

Around the Sections

(Continued from page 390)

Mining Club, H. R. Rice, head of the Dept. of Mining Engineering, University of Toronto, a former editor of the *Canadian Mining Journal*, was the featured speaker. He discussed the status of Canadian mining—the Canadian mineral industry in relation to the American economy, postwar developments in the Canadian industry as compared with the U.S., and the size and growth of Canadian industry in that period. He also discussed the newest and most significant Canadian enterprises.

• The **Pennsylvania-Anthracite Section** had as their guest speaker on November 8 Toby Eichler, Lehigh Valley Coal Co., at the meeting at Kingston House, Kingston, Pa. Mr. Eichler's subject was *Revision of the Dorrance Breaker to Heavy Media* and George Walker, American Cyanamid Co., contributed additional information on the subject by means of diagramatic sketches on slides. Chairman of the technical section was E. T. Powell, mining engineer, Glen Alden Corp., and chairman of arrangements was A. F. Hutcheson, district manager, Atlas Powder Co.

• The **Reno Subsection** meeting was held at the Mapes Hotel on January 10. Fred Lohse, Kaiser Aluminum and Chemical Corp., outlined the program of the 1958 Pacific Southwest Mineral Industry Conference to be held in San Francisco on March 27 to 29. He also spoke on the organization of the Kaiser Industries.

Subsection officers for 1958 were installed. E. F. Lawrence is chairman, Milton Steinheimer is vice chairman, and J. K. Jones is Secretary-Treasurer.

• Guest speaker at the **Southeast Section** meeting, September 27, at the Hotel Andrew Johnson in Knoxville, Tenn., was Donald J. Belcher. Mr. Belcher, president of Donald J. Belcher & Assoc. Inc., Ithaca, N.Y., discussed aerial photography and its role as a tool in geological survey. Dr. Belcher is also head of the Airphoto Research Center at Cornell University. His talk was part of the Section's convention, which included business sessions and study groups on September 27 and a field trip on September 28 through the Young Mine, American Zinc Co., Mascot, and a visit to the Oak Ridge National Laboratory. Other speakers at the meeting were William Black, manager, American Zinc Co. of Tennessee; Fred W. Drotsen, section head, Titanium Sponge Development Cramet Corp.; John F. Lord, American Smelting and Refining Co.; A. J. McDonnell, Foote Mineral Co.; K. B. Brown, Chemical Technology Div., Oak Ridge National Laboratory; and R. E. Smason, American Limestone Co.

M. B. Lanier was guest speaker at the January meeting of the Southeast Section. President of the Ingalls Shipbuilding Co., he discussed the *Glacier*, an Ingalls' built Navy icebreaker. Mr. Lanier discussed International Geophysical Year studies made by American forces at the South Pole.

• **El Paso Section** met at the Hotel Cortez, El Paso, Texas, on January 8. Mrs. Gladys Babson Hannaford, Ayers Advertising Agency, discussed diamonds and diamond mining in Africa. She works on the DeBeers account, diamond firm.

The following officers were elected: chairman, John E. Douglas; vice chairman, K. DeAtley Loughridge; secretary-treasurer, Guy E. Ingersoll; and directors, M. S. Bell, Jack Nelson, Wm. F. Grimshaw, George L. Dickinson, Ben E. Adams, Charles E. Evans, and Fred Fox.

• The **Black Hills Section** met at the School of Mines Dormitory, Rapid City, S.D., on September 25. Speaker of the evening was David Murray, a senior high school student from the Lead High School in Lead, S.D. Mr. Murray, winner of the annual student prize paper award, spoke on *Methods of Mineral Analysis.*

At the November 14 meeting in the Presbyterian Church, Rapid City, Joseph L. Gillson, du Pont de Nemours Co. and Vice President of AIME, discussed *Industrial Minerals.* In his talk Dr. Gillson pointed out the many facets of this great mineral industry and gave illustrative examples to show that the industrial minerals industry exceeds the metals industry at a ratio of 3:2. He emphasized what could be expected if the population of the world increases and how this population could be fed and clothed by the products that are coming out of the research laboratories throughout the world.

Black Hills Section officers are as follows: Edward H. Stevens, chairman; Rex Tario, first vice president; Frank M. Howell, second vice chairman; Joel K. Waterland, secretary-treasurer; and R. H. Richards, F. L. Partlo, Paul A. Miller, James M. Riley, and Harold D. Webb, executive committee.

Paul Anderson, head of the metallurgical department of the South Dakota School of Mines and technical director, was the speaker at the January 23 meeting in the Rod and Gun Club, Lead, S.D. He discussed the research work which is being done on nuclear and atomic physics at Brookhaven National Laboratory on Long Island. He has spent the past two summers there. Part of the agenda for the meeting was the appointment of Rex Tario as chairman of the membership committee and Frank M. Howell, Jr., as chairman of the program committee.

• At the January 10 meeting of the **St. Louis Section,** held at the York Hotel, R. M. Edwards was the principal speaker. Mr. Edwards, superintendent of development and research at Mallinckrodt Chemical Works, Uranium Div., spoke on the general processes used in the reduction and purification of uranium salts received from the Colorado Plateau, Canadian, and South African uranium mills. Samples of the purified uranium salts (black, yellow, and green) were displayed as well as a small ingot of uranium metal.

At the Section meeting on February 14 Jules C. George spoke on the subject *An American in Turkey.* Mr. George, who retired in January 1957 after 24 years with the Cleveland Rock Drill Co., was sent to Turkey by LeTourneau-Westinghouse Co. as a rock drill specialist. Mr. George discussed his recent experiences during a year's stay in Turkey as an instructor to the Turkish Republic Highway Dept. in rock drill practice and in maintenance for LeTourneau-Westinghouse which furnished Turkey with most of their highway machinery.

• **Washington, D.C., Section** met at the Cosmos Club on January 7 to hear Louis Newman, U.S. Bureau of Mines, describe his recent trip to Russia. In July Mr. Newman was a member of the Congressional Peat Mission and visited peat mining operations in Russia, Germany, Austria, and Finland. His talk was mainly concerned with mechanization of the Russian peat mining and a film was shown on the industry of Russia.

The session held its 32nd annual oyster party on February 4 at the National Press Club. The evening's proceedings were started with cocktails and oysters on the half shell and a buffet supper featuring oysters followed.

• L. Newton Thomas, president of National Coal Assn., spoke at the annual meeting of the **Central Appalachian Section** in November. The meeting was a joint one with the West Virginia Coal Mining Inst. held in White Sulphur Springs. Mr. Thomas said that the coal industry, despite its vast advances in modernization, needs more engineers than ever before to find better mining methods and new uses for coal. He stressed the need for attracting more high school students into the industry and urged scholarships and summer jobs for college men.

•The **Adirondack Section** will again sponsor an essay contest open to freshmen in the Mineville, Port Henry, Moriah, and Willsboro schools located within the Section. George E. Gidmay, chairman of the committee of student affairs, reports that

(Continued on page 395)

SME Directors in 1958

(*Continued from page 391*)

in St. Louis where his responsibilities cover the company's phosphate mining operations.

A native of Burley, Idaho, a small farming town in the southern part of the state, Mr. Emigh is a graduate of Idaho in 1932 with a B.S. in mining. He later received an M.S. in metallurgy from his alma mater and a Ph.D in geology from the University of Arizona. His career in the mineral industry field has been in three major areas—mining, metallurgy, and geology. For 12 years, from 1937 to 1948, Mr. Emigh was associated with U.S. Vanadium Corp., a subsidiary of Union Carbide Corp. Prior to this time, his experience was confined to a number of short-time jobs in various mines and mills in the west and with the USGS during summer vacations.

His career with U. S. Vanadium can be divided roughly into three four-year sections: field examinations of mining properties in the west, mining operation and administration in the same region, and administration with the New York office as headquarters. Mr. Emigh joined Monsanto Chemical in 1949 as a consultant in the west and spent the next two years examining, sampling, and otherwise evaluating phosphate deposits. He became a formal employe in 1951, serving until 1953 as production superintendent of the electric furnace operation built at Soda Springs, Idaho, to produce elemental phosphorus. He has held his present position of director of mining since 1953.

Mr. Emigh has been a member of AIME since 1952 and at the present time is busy serving as general chairman for the Mid-America Minerals Conference (see page 385) in St. Louis in October.

James Donald Forrester is Western Regional Vice President and was chosen in 1957 to serve a three-year term to expire in 1960. The author of over 40 published technical papers and text books on mining and geological subjects, he is dean of the College of Mines, University of Arizona, and director of the Arizona Bureau of Mines.

Dr. Forrester was born in Salt Lake City in 1906 and attended the University of Utah, graduating in 1928 with a B. S. in geological engineering. He later received the professional degree of geological engineer from the University. Dr. Forrester continued his education at Cornell University for advanced degrees in geology—M.S. and Ph.D.

Although the major part of his professional career has been spent in the educational field, he has had ample contact with industrial and mining concerns, particularly with the Anaconda Copper Mining Co., whom he served as assistant mine geologist, 1929 to 1932, and mining geologist and field engineer, 1935 to 1939. During the latter years he also spent some time with International Smelting & Refining Co. on leave from Anaconda. Dr. Forrester did a strategic minerals study of the Pine Creek zinc area (Coeur d'Alene district) in 1943 for the U. S. Geological Survey as field geologist in charge of the program. He has performed numerous consulting commissions on mines and mineral deposits in various sectors of the U. S.

Dr. Forrester actually began his teaching experiences while still studying for his advanced degrees, first as an assistant instructor in metallurgy at the University of Utah and later as assistant instructor in geology and instructor in economic and engineering geology at Cornell. Leaving Anaconda in 1939, he became professor and head of the Dept. of Geology at the University of Idaho. Before assuming his present post as dean at the University of Arizona, Dr. Forrester held major faculty posts at the Universities of Missouri and Idaho.

Around the Sections

(*Continued from page 394*)

Republic Steel Corp. will sponsor the contest in the Mineville, Port Henry, and Moriah schools, and the Cabot Minerals Div. of Cabot Carbon Co. will sponsor the Willsboro school contest. The contest is intended to stimulate interest in careers in the mineral industry and to especially encourage students with an interest in engineering to plan their careers at the freshman level. The essays are to be confined to one particular topic of geological, mining, or mineral preparation.

• The **Norwood Mining and Metallurgical Society,** Student Chapter at University of Kentucky, met in October and November to hear C. S. Crouse and H. W. Maynor of the Dept. of Mining and Metallurgical Engineering faculty; A. C. Hensel, Albion Malleable Iron Co.; and Norman Yarborough, assistant manager of the U.S. Steel Corp.'s coal mines at Lynch Ky. Field trips were held during December. Metallurgy students toured the plant of Tube Turns in Louisville. Miners and metallurgists visited Armco Steel at Ashland, Ky. The miners attended the annual meeting of the Kentucky Mining Inst. in Lexington, Ky. Senior students of mining engineering visited Tennessee Copper Co., the American Zinc Co. of Tennessee, and the Lynch district of U.S. Steel Corp.

• Winner of the student prize contest held by the **Central New Mexico Section** was Morris T. Worley, senior at the New Mexican Inst. of Mining and Technology in Socorro. The winning paper, for which he received the A. B. Woodward award, was on the subject of *Practical Dust Control in Metal Mines.* The award was made at the annual meeting of the Section held in Albuquerque, N. M., on January 18.

Montana Symposium On Mining Is Scheduled

The Dept. of Mining Engineering at Montana School of Mines, actively assisted by AIME, Mining Assn. of Montana, The Anaconda Co., the Montana Soc. of Engineers, and the Montana School of Mines, will sponsor a symposium concerned with the hydraulic emplacement of mine stope fill. The symposium will be held on the campus of the School of Mines in Butte, on May 9 and 10.

The object of the symposium will be to allow some mine operators to present papers outlining their solutions to specific problems in the use of hydraulically emplaced fill. It is hoped that other operators will be able to explore for solutions to their own problems through a free interchange of ideas during the discussion period following each paper or each session. The subject matter for the series of papers will be selected to provide as complete a coverage of the most recent developments in the field as time will allow.

There will be sessions covering such aspects as the use and application of hydraulic fill in which the modification to mining methods that result from the use of this technique will be described. A discussion of the use of hydraulic fill for fighting mine fires and as a stabilizing factor providing regional support to ground adjacent to active mines will be held. The problems associated with conditioning sand and tailings for the most efficient transportation, placement, and drainage of the fill after it is in place, and results of the most recent research into the design aspects of sand fill systems will be discussed. Industry representatives from Canada and all over the U. S. will attend.

The group responsible for the general arrangements consists of Edwin G. Koch, president, Montana School of Mines, who is chairman; Edward P. Shea and Clifford Hicks, AIME; Edward Renouard and Richard M. Stewart, The Anaconda Co.; William G. Maloney, John Bley, and Roy McLeod, Mining Assn. of Montana; Robert L. Olund, Montana Soc. of Engineers; and Arthur E. Adami, Montana School of Mines. William A. Vine, Dept. of Mining Engineering, is responsible for the technical program and is assisted by Stewart Hurlbut, Research Dept., The Anaconda Co. Koehler S. Stout, Dept. of Mining Engineering, is in charge of publicity.

Personals

(*Continued from page 393*)

Jack H. How, president of Western Machinery Co., was recently elected second vice president of the San Francisco Chamber of Commerce. During the past year, Mr. How had served as third vice president.

Melvin A. Buettner, formerly application engineer for the American Air Filter Co., is presently holding the position of sales engineer for Air Filter & Equipment Co.

C. A. Mark, previously geological engineer—Exploration Div., the Colombia-Geneva Steel Div., U. S. Steel Corp., is presently assistant supervisor—Exploration Div. of the Colombia Iron Mining Co., subsidiary of U. S. Steel Corp. for exploration in 11 western states.

Thomas Hart, formerly mine engineer with the White Pine Copper Co., is now mine foreman for Kermac Nuclear Fuels Inc., Grants, N. M.

O. D. Niedermeyer has been appointed general manager of the St. Louis Smelting and Refining Div. of National Lead Co. He continues as a vice president and director of Nickel Processing Corp.

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W. F. Stowasser has been appointed process development engineer of the Processing Machinery Dept., Allis-Chalmers Manufacturing Co.

John S. McNabb, Jr., who joined Twin Star Industries Inc. as manager of mines in July, was also elected vice president in charge of mining operations of the Austin, Texas, concern.

Robert L. Halsted is now general manager of the Industrial Equipment Div., Allis-Chalmers Manufacturing Co., succeeding **P. F. Bauer** who is now managing director of Allis-Chalmers International, a new operating Division. **Edward H. Baxa** is manager of the processing machinery department, succeeding Mr. Halsted.

Elliot Gillerman is now associate professor of geology at the University of Texas, teaching courses in mineralogy and economic geology. He has been a member of the staff of the university.

Stanley W. McDougall is manager of Kellogg, Idaho, operations for The Bunker Hill Co. He had been manager of mines before assuming his new post.

Raymond T. Whitzel has retired as vice president and general production manager of Aluminum Co. of America, and has been succeeded by **Harold C. Erskine,** assistant general production manager. Mr. Whitzel, who has seen over 42 years of service with Alcoa achieved during his career a number of patented improvements in aluminum manufacturing processes and distinguished himself in plant organizational responsibilities.

Glen A. Boyd has been transferred from St. Paul to the newly opened Seattle office of the Northern Pacific Railway Co.'s Geology Div.

Robert D. O'Brien has joined the sales engineering staff of Southwestern Engineering Co., Los Angeles. He had been factory representative in the Far East for The Eimco Corp.

R. D. O'BRIEN

James I. Craig has been transferred by the New Jarsey Zinc Co. from Hanover N. M., to Treadway, Tenn., where he is superintendent of the company's Treadway operation.

Roland W. Merwin was recently appointed general manager of Negociacion Minera Santa Maria de La Paz, Matehuala, Mexico. He had been associated with Neptune Gold Mining Co., Bonanza, Nicaragua.

William G. Freeman and **David C. McCrillis** were among a group of ten students from the U. S. and Canada who were hired by Cerro de Pasco Corp. for summer work and study in South America. Both, students at the Mackay School of Mines, University of Nevada, were located in the Andes—Mr. Freeman at the company mine in central Peru and Mr. McCrillis at the San Cristobal mine.

Roscoe H. Channing has retired as president and director of Hudson Bay Mining & Smelting Co. Ltd. He has been succeeded as president by **C. V. Whitney,** chairman of the board. A board member since the company's organization in 1927, Mr. Channing became president in 1931.

Michael G. Holt, who graduated in August 1957 from Texas Western College, El Paso, Texas, is junior engineer for the International Nickel Co. of Canada Ltd. in Surbury, Ont., Canada.

Victor J. Pittson, mining engineer for Eldorado Mining & Refining Ltd., has been promoted to senior planning engineer. He had been techincal assistant to the vice president in charge of operations at the Ottawa head office and has been transferred to the Beaverlodge operation in his new capacity.

Raymond K. Robbins, previously assistant geologist with the Tennessee Coal and Iron Div., U. S. Steel Corp., is now a geologist for the Texas Petroleum Co., Peruvian Div.

Arthur W. Lankenau, formerly research metallurgist with the M. A. Hanna Co., is now a department head for Union Carbide Nuclear Co., Uravan, Colo.

Lewis C. Black, previously sales manager-large machines with the Bucyrus-Erie Co. has been appointed assistant general sales manager in charge of sales of large machines and blast hole drills.

Otto E. Haaland, previously mining engineer for his own Mining Engineering Service, is now mining engineer for the C. T. Takahashi and Co. Inc., Seattle.

D. J. Straw has returned to Canada to resume his duties with Johns-Manville Co. Ltd. in the Exploration Dept. at Asbestos, Que. Mr.

Straw had been acting for the past two years as chief geologist for Rhodesian Asbestos Ltd., Mashaba, Southern Rhodesia, on loan from Canadian Johns-Manville.

Edmund A. Prentis, mining engineering graduate of Columbus University in 1906, has been awarded the 1958 Alexander Hamilton Medal, given annually by the graduates of Columbia College to a former student or college faculty member for "distinguished service in any field of human endeavor." The medal will be presented at dinner on April 13 at the Morningside campus. Mr. Prentis, for many years a member of the New York engineering firm of Spencer, White and Prentis, has been active in alumni activities of the college and university.

Tom L. Pittman, formerly associated with Knob Hill Mines Inc., is now mine examination and exploration engineer for U. S. Bureau of Mines in Juneau, Alaska.

A. K. HEYDRICK

R. B. Nelson is now mine project engineer for International Minerals & Chemical Corp., Denver. He had been chief engineer, Big Indian Mines, Hidden Splendor Mining Co.

Walter Riethmeier is now field mechanical engineer for Western Knapp Engineering Co. at the Phillips mill in the Ambrosia Lake area of New Mexico. He has been design engineer for the company.

Fred D. Hoover is superintendent of the Gilbert iron mine, Gilbert, Minn., Oliver Iron Mining Div., U. S. Steel Corp.

H. R. Moorhouse, formerly secretary and treasurer, Arthur G. McKee & Co., has been elected executive vice president.

Robert W. Martin is now buyer in Duluth purchasing department, Oliver Iron Mining Div., U. S. Steel Corp.

Richard J. Lund and **Bertrand A. Landry** have been promoted to assistant technical directors at the Battelle Memorial Institute. **David D. Moore** has been named manager of the Dept. of Economics.

At the recent annual meeting of the Virginia Coal Operators Assn., **Harry W. Meador, Sr.,** was elected president for the coming year. Mr. Meador succeeded **R. H. Hughes,** president of the Clinchfield Coal Corp., who was named vice president of the association. **E. H. Robinson** was reelected secretary-treasurer. Additional directors are **John Mayhew,** vice president of the Blue Diamond Coal Co., and **J. B. Taggart,** president of the Wise Coal and Coke Co.

A superior performance citation and a cash award of $500 from the U. S. Dept. of the Interior have been conferred upon **Albert E. Long** of Reno, Nev., a U. S. Bureau of Mines research engineer at the USBM Rare and Precious Metals Experiment Station at Reno. The award was made in recognition of Mr. Long's development of a technique for taking advantage of varying hardness of diamonds that has enabled the domestic mining industry to save an estimated $4 million a year.

Allen K. Heydrick has been appointed to the new position of education and training director of Link-Belt Co. He had held a similar position at National Steel Corp.

Heikki V. Tuominen has been named associate professor of geology at Lehigh University. Dr. Tuominen had previously been chief geologist for the Finnish Ore Co. of Helsinki, Finland, engaged in magnetic and geologic prospecting in Finland and Lapland.

A. BLAIR

Allen Blair has been appointed product designer of The Long Co., Oak Hill, W. Va., manufacturers of mining equipment and conveying machinery. He had been associated with Royalty Smokeless Coal Co. and National Mine Service Co.

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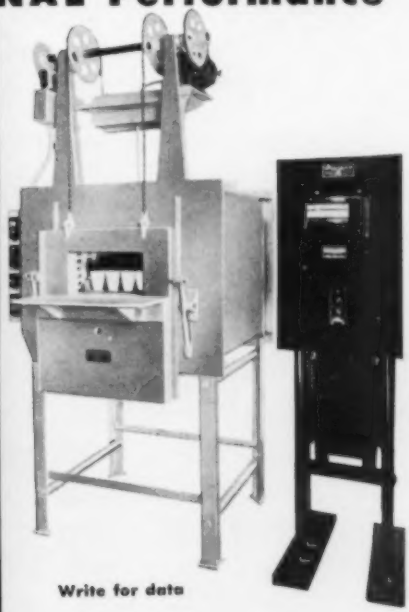

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The following is a listing of all 1958 SME Annual Meeting papers (given Feb. 17 to 20, 1958, in New York) preprinted and still available. Preprints may be obtained from SME Headquarters, 29 W. 39th St., New York 18, N. Y., by mailing in coupons (received with 1958 dues bill), properly filled out. Additional coupon books may be obtained from SME for $5 a book (10 coupons) for *members* or $10 a book for *nonmembers*. Each coupon entitles the purchaser to one preprint.

5817A1—The Pima Open Pit and Haulage Facilities by Robert Thurmond.
5817A2—Mining of Magnetite and Martite at Benson Mine by Arthur F. Peterson, Jr., and Wm. P. Bach.
5817A3—Estimating Data for Haulage Trucks—Open Pit Mines by Howard Wilmeth.
5817A4—Problems in Mechanization in Primitive Countries by James V. Thompson.
5817A5—Intrusions and Ore Deposition in New Mexico by Charles Belt, Jr.
5817A6—Some Considerations in Determining the Origin of Ore Deposits of the Mississippi Valley Type by E. L. Ohle.
5817A9—Time Aspects of Geothermometry by R. J. P. Lyon.
5817A10—Ball Mill Performance at Super Critical Speeds by R. T. Hukki.
5817A11—A Study of Different Types of Steel for Grinding Media at Climax by F. Windolph and E. J. Duggan.
5817A12—Single-Stage vs Two-Stage Grinding at Homestake by C. E. Schmidt and F. M. Howell, Jr.
5817A18—Coal Mine Bumps Can be Eliminated by H. E. Mauck.
5817A20—Some Notes on the Principles of Mine Hydrology by H. E. LeGrand.
5817P1—Preplanning Safety in the Uranium Mining Industry by John E. Bailey.
5817P2—Increased Safety, Better Production, Through Use of Communication and Electronic Equipment by Earl A. Berry.
5817P3—Symposium on Safety and Health by James Westfield, John A. Johnson, Henry N. Doyle, and Miles P. Romney.
5817P5—Lineament Tectonics and Some Ore Deposits of the Southwest by Evans B. Mayo.
5817P9—Relation of Magnetic Susceptibility to Composition in Sphalerite and Minerals of the Wolframite Group by E. M. Spokes and D. R. Mitchell.
5817P10—The Metallurgical Story at Inspiration by C. B. Kettering and K. L. Power.
5817P12—Collector Mixtures and Collector Frother Emulsions in Sulfide Flotation by Arvid E. Anderson.
5817P14—Application of Mineral Dressing Fundamentals to the Solution of the Fine Coal Problem by M. C. Chang and John Dasher.
5817P17—Removal of Heat in Cement Grinding by J. R. Tonry.
5817P18—A Critical Study of Thickening by A. M. Gaudin, M. C. Fuerstenau, and S. R. Mitchell.
5817P19—The Application of a Jig for the Beneficiation of Sand and Gravel by John Meckenstock.
5817P20—The Application of Horizontal-Type Filters to the Metallurgical Industries by W. F. White.
5817P24—Economics Evaluation of an Industrial Mineral Project by J. E. Castle.
5817P25—Current Development in Gravel Beneficiation by W. L. Price.
5817P26—The Use of DSM Screens in a Heavy Media Cyclone Plant by W. R. Van Slyke, James Stukel, and L. D. Keller.
5817P27—Pima Mining Company Concentrator by G. A. Komadina and R. W. Herlund.
5818A1a—The Use of Ammonium Nitrate for Blasting at Mesabi Range Mines by Charles H. Grant.
5818A1b—The Use and Economy of Ammonium Nitrate Fertilizer Grade in the Open Pit Operations of the Anaconda Company in the Western United States and Mexico by A. C. Bigley.
5818A1e—Blasting with Ammonium Nitrate by Lewis J. Patterson.
5818A1d—Blasting with Prilled Ammonium Nitrate Fertilizer by W. M. Chapman.
5818A2a—Conveyor Belts at Miami Copper Co. by Benjamin R. Coil and James B. Fletcher.
5818A2b—Underground Conveyor Experience at Inland's Iron Mines by Howard M. Graff and James R. Gronseth.
5818A3—Raising by Use of a Cage by John C. Wangaard.
5818A4—Lac Tio Ilmenite Deposit by E. O. Dearden.
5818A5—The Titanium Sands of Southern New Jersey by Frank J. Markewicz, Daniel G. Parrillo, and Meredith E. Johnson.
5818A12—Effect of Soil Contamination on Geochemical Prospecting in the Coeur d'Alene District, Idaho by F. C. Canney.
5818A13—Significance of Geochemical Distribution Trends in Soil by D. H. Yardley.
5818A15—Solubility of Some Metal Ethyl Xanthates by P. S. M. van Heteren and P. L. DeBruyn.
5818A16—Activation and Deactivation Studies with Copper on Sphalerite by A. M. Gaudin, G. W. Mao, and D. W. Fuerstenau.
5818A17—Correlation of Contact Angle, Adsorption Density, Zeta Potential, and Flotation Rate by D. W. Fuerstenau and A. M. Gaudin.
5818A18—Experience with the FluoSolids Fine Coal Dryer by M. W. Brandt.
5819A1—Some Legal Problems Encountered in the Acquisition of New Mineral Property by R. E. Driscoll, Jr.
5819A3—Economics of Geologic Exploration by Donald M. Davidson.
5819A4—Valuation of a Mineral Deposit by A. L. Slaughter.
5819A6—Chemical Fuels and Other Organometallic Compounds—Their Impact on the Mineral Industry by Donald Gibbons.
5819A7—Recent Developments in the Allowances for Percentage Depletion by Frank H. Madison.
5819A8—An Exciting Future Ahead with Lead—An Industry Program by R. L. Ziegfeld.
5819A9—Comparison of 2400 and 4160 Volt Distribution Systems for Concentrators by R. M. Wilson.
5819A10—Earthquake Design for Metallurgical Plants by W. B. Hester.
5819A11—Tailings Line Design at Affected by pH by A. A. Wallach.
5819A12—Factors in the Selection of Motors and Speed Reducers for Conveyor Drives by Clark B. Risler.
5819A13—Coal Mine Personnel Selection by C. R. Nailler.
5819A15—The Application of Industrial Engineering in Coal Mining by Charles W. Rountree, Jr.
5819A18—Commercial Thorium Ores by H. E. Kremers.
5819P1—Magnetic Separation of Ores—History and New Foreign Developments by L. A. Roe.
5819P2—Dry Magnetic Cobbing Separations by Wm. M. Aubrey.
5819P4—Megnetic Separators in the Heavy Media Process by K. E. Merklin.
5819P5—Benefits Which Derive From the Use of A.C. Power Underground by C. S. Conrad.
5819P6—Continuous Coke Production on a Water-Cooled Grate Stoker by R. J. Grace and Jos. D. Doherty.
5819P7—Pioneering Carrier Communication and Control in Mines and Mills by W. Porter Place.
5819P9—Underground Movement and Subsidence Over the U. S. Potash Co. Mine, Div. of U. S. Borax and Chemical Corp. by E. H. Miller and F. L. Pierson.
5819P10—Boron—Its Past, Present, and Future by D. S. Dinsmoor and Frank Weishauph.
5819P11—Uses of Standard Ottawa Testing Sands by Paul A. Gerding.
5819P12—Utilization of Pennsylvania Slate for Expanded Aggregate by Frank D. Hoyt.
5819P15—Jackling Lecture—Planning Deep Mining at Homestake by A. H. Shoemaker.
5820A2—Statistical Method of Calculating and Analyzing Ore Reserves by John A. Patterson.
5820A6—Rapid Field Methods for the Colorimetric Determination of Nickel for Use in Geochemical Prospecting by Harold Bloom.
5820A8—A Nuclear Detector for Beryllium Minerals by T. Cantwell, N. C. Rasmussen, and H. E. Hawkes.
5820A11—FluoSolids Roasting of Sulfides for Recovery of Copper, Iron, and Sulfur by H. Kurushima and R. M. Foley.
5820A14—Recovery of Iron Ores Containing Titanium, Manganese, Chromium, and Alkali Metal Sulfates by A. G. Oppegaard, O. Moklebust, and G. G. Reed, Jr.
5820A15—Resin-in-Pulp Process at Mines Development Inc. by H. D. Webb, G. F. Richards, and G. T. Bator.
5820A16—Climax Uranium Co.'s Approach to Vanadium Recovery by Solvent Extraction by R. E. Musgrove, E. E. Maurer, and R. E. Fischer.
5820A17—Amine Extraction of Port Radium Leach Liquor by M. E. Grimes.
5820A18—New Solvent Extraction Techniques for Uranium Purification by R. S. Long, J. E. Magner, and D. A. Ellis.
5820A19—Safety Features in the Design and Development of Ireland Mine by Geo. W. McCaa.
5820P1—The Bicroft Uranium Mines Operation by J. D. Bryce and J. M. Thompson.
5820P3—Mining at Eagle-Picher's Esmeralda Unit, Parral, Mexico by R. B. Taylor.
5820P4—The Moa Bay-Port Nickel Project—New U. S. Nickel and Cobalt From Cuban Ores by Forbes K. Wilson.
5820P9—Meteorological Influence on Radon Concentration in Drill Holes by Allan B. Tanner.
5820P13—Automatic Weighing and Ratioing of Solids by Thomas L. Mell.
5820P15—Hydraulic Solids Flowmetering by E. J. Klein and E. F. Nagle.
5820P16—Gamma Ray Gages in Beneficiation Plants by John R. Riede.
5820P19—Roof Bolting in Kentucky Coal Mines by George K. Martin.
5820P20—Handling Air from Conventional Coal Dryers by M. I. Dorfan and Raymond Mancha.

Allis-Chalmers Manufacturing Co., Milwaukee, named three vice presidents: **E. J. Mercer,** general manager, Construction Machinery Div.; and **William M. Wallace,** general manager, General Products Div. **A. D. Dennis** was elected secretary, succeeding **W. E. Hawkinson** who retired in November. **John J. Nolan** was named a representative in the New York district office to handle crushing, cement, and mining sales. **C. R. Burnett** was named engineer-in-charge, pyro-processing machinery.

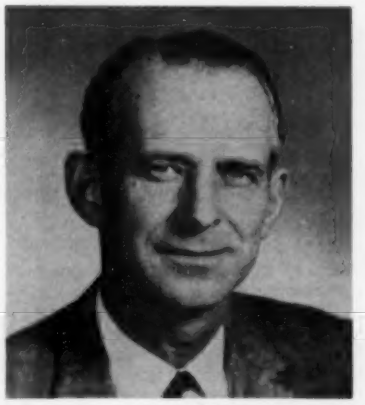
R. E. Shreve has been appointed mill superintendent at the Shiprock, N. M., uranium processing mill of Kerr-McGee Oil Industries Inc.

Rudolf A. Sesink Clee has graduated from the Technological University, Delft, Holland, as a mining engineer, and has emigrated to the Union of South Africa.

James P. Blaisdell, a specialist in labor industrial relations administration, is the newest member of the Employee and Public Relations Div. of The Bunker Hill Co. at Kellogg, Idaho. Mr. Blaisdell, a graduate of Harvard Law School, has been named assistant manager of the division and labor relations administrator.

Four students at two Utah Universities were selected to share scholarship grants amounting to $2000 and given by the Kennecott Copper Corp. for the 1957-1958 term. **Roger Hendrickson** of Gunnison, Utah, and **Harry Hecht** of Powell, Wyo., both received a $500 grant to Brigham Young University. Receiving a $500 grant each at the University of Utah were **Virgil R. McFarlane** of Salt Lake City, and **Richard Knostman** of Wamega, Kan.

George R. Westby and **Mrs. Lucy Bryan McMillin** were elected to the posts, respectively, of treasurer and assistant secretary of Cerro de Pasco Sales Corp., New York.



J. A. NISSEN

James A. Nissen was recently appointed general sales manager for

SYNTRON SHAKER CONVEYORS

50 ft. model with extension flare sides

Handle dry or damp, hot, cold or corrosive material at high rates

SYNTRON Shaker Conveyors are multi-purpose units designed for high speed conveying of most bulk materials pre-heating and drying bulk materials or as picking tables for manual removal of foreign objects from bulk materials.

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Vibratory Screens	Electric Heating Panels
Shaker Conveyors	Electric Heating Elements
Vibratory Elevator Feeders	Sinuated Wires
Weigh Feeders	Shaft Seals
Packers and Jolters	Electric Hammers
Hopper Feeders	Concrete Vibrators
Lapping Machines	Paper Joggers

Our representatives will be glad to work with you in selecting the proper equipment for your operation.

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SYNTRON COMPANY

554 Lexington Ave. Homer City, Penna.

Denver Equipment Co. Well known throughout the industry for his activities in mining, milling, mill design, and construction, he had been a Denver Equipment dealer in the San Francisco area.

New faculty appointments at Colorado School of Mines were announced recently. **Charles M. Shull, Jr.,** has been appointed assistant professor of chemistry. He has worked in education as an instructor at the University of Tulsa and in private industry as an engineer and metallurgist. **Maynard F. Ayler** has been appointed an instructor in mining. A graduate of Colorado School of Mines, he had worked as engineering geologist and surveyor for the Government and in his own consulting geologic business. **David A. Rowland** has been named instructor in petroleum engineering. He was a reservoir engineer with Tidewater Oil Co.

Jerome V. Sparapani is erecting engineer for cement, crushing, and mining machinery in the service section, Allis-Chalmers Manufacturing Co., Milwaukee.

S. G. Lasky, staff assistant for minerals in the office of the Secretary of the Interior, spent two weeks in February in Havana, Cuba, as mining and minerals consultant to the Cuban Government in connection with the first national symposium on the natural resources of Cuba.

O. SCHELLENBERGER

Otto Schellenberger, Detroit district sales manager, Thor Power Tool Co., has been named "Manager of the Year" in the firm's 1957 international sales program. Second and third place winners were **Frank J. Schiel,** Chicago district sales manager, and **Robert C. Williams,** Toronto, Canadian sales manager.

Henry J. Petrie, formerly mining industry sales representative for Allis-Chalmers Manufacturing Co., has been named sales representative for Vitro Engineering Co., New York, a division of Vitro Corp. of America.

Stewart J. Cort, retired vice president of Bethlehem Steel Co., has presented a $35,000 gift to Lehigh University, Bethlehem, as an endowment fund for scholarship aid. Mr. Cort, an active alumni of Lehigh and a member of the board of trustees, was awarded an honorary doctor of engineering in 1948. The grants from the Stewart J. Cort Fund will be given to candidates for admission to the College of Engineering, preferably in the metallurgical or combined arts-metallurgy programs.

B. MAYO

Bruce Mayo has been appointed district manager, Birmingham, for the Link-Belt Co. Previously sales engineer in the Louisville district office, Mr. Mayo replaces **J. Ross Arnold** who has been named to handle a special assignment at the Link-Belt plant at Colmar, Pa.

Carter Kissel has been elected president and **Cleve H. Pomeroy,** chairman of the board, National Malleable & Steel Castings Co. Cleveland. Mr. Kissell, a partner in the law firm of Jones, Day, Cockley & Reavis, has been legal counsel of National Malleable since 1941 and a member of the board of directors since 1954. Mr. Pomeroy, who joined the firm in 1920, has been president since 1946.

Ernest J. Gleim, who retired in 1956 as chief of the U. S. Bureau of Mines' Branch of Electrical-Mechanical Testing, Pittsburgh, has been awarded the U. S. Dept. of Interior Distinguished Service Award and Gold Medal. His specialty for over 41 years has been research on coal mine safety.

William H. McCracken has been transferred to Lima, Peru, by Harbison-Walker Refractories Co. He is manager, Refractarios Peruanos S. A.

Eugene E. Quenon has been honored by the U. S. Dept. of the Interior with its Distinguished Service Award and Gold Medal in recognition of his 28 years service in the health and safety activities of the U. S. Bureau of Mines. Mr. Quenon, who had been USBM district health and safety supervisor, is now director of safety for Peabody Coal Co.

Thomas A. Stewart, formerly mine superintendent, Cerro de Pasco Corp., Morococha, Peru, is now mine superintendent for Compania Minera Castano Viejo, National Lead Co. subsidiary in San Juan, Argentina.

Leon F. Barber, who had been chief mining engineer for Goodnews Bay Mining Co., is now associated with Cia Minera Choco Pacifico, S. A., as design engineer. He is doing dredge modification and design work for the company, a subsidiary of South American Gold and Platinum Co. Inc. in Medellin, Colombia.

Frank F. Aplan has joined the technical staff, Metals Research Laboratories, Electro Metallurgical Co., Niagara Falls, N. Y., a division of Union Carbide Corp. He has been assigned to the minerals and chemical engineering group and will be exploring new techniques of ore beneficiation. Prior to joining Electromet, Dr. Aplan had been associated with Climax Molybdenum Co. and Kennecott Copper Corp.

Harvey C. Shaughency, formerly with Joy Manufacturing Co., has joined the staff of Thompson-Berg Co., Iron Mountain, Mich., as sales manager.

H. C. SHAUGHENCY

Renato Zoppis, consulting geologist for the Ministry of Commerce of Nicaragua, has moved to Bolzano, Italy, and has been nominated Consul of the Republic of Nicaragua in that city in addition to his consulting assignment. He also reports that he is the owner and manager of mineral concessions for radioactive minerals in Italy.

Newell W. Roberts has retired from Berwind-White Coal Mining Co., New York, and is residing in Hampton, Conn.

P. G. Zambas is associated with Hellenic Mining Co., Nicosia, Cyprus, where he is in charge of sinking a shaft toward a new orebody.

George C. Trevorrow, Jr., formerly with the U. S. Army, is now working as a mining engineer for Buckeye Coal Co., Nemacolin, Pa.

John W. Lampert has returned to Rosiclare, Ill., after three years at Paranam, Surinam, S. A.

Oscar Lee has retired as preparation engineer with Republic Steel Corp. and Researve Mining Co. He is still associated with the companies on a consulting basis in the field of ore beneficiation. He has established his home in Ormond Beach, Fla.

Robert D. Ferron, district geologist in charge of South American exploration for Kennecott Copper Corp. has retired and will reside in California.

L. M. Coffey has been appointed Far Eastern representative for Joy Manufacturing Co. and Joy Sullivan Ltd. and will make his headquarters in Singapore.

G. G. Hatch has been appointed president of W. S. Atkins & Assoc. Ltd., a consulting engineering firm with offices in Toronto and Montreal. A graduate of McGill University and Massachusetts Institute of Technology, he was recently plant superintendent of the Quebec Iron and Titanium Corp.

G. G. HATCH

E. Warren Peterson is now associated with Caland Ore Co. Ltd., Atikokan, Ont., Canada, a subsidiary of Inland Steel Co. Mr. Peterson has been a mine superintendent for Inland Steel.

Jerry M. Whiting, formerly mining engineer with Aluminum Co. of America, has joined the staff of *Mining Congress Journal*, Washington, D. C., as assistant editor. Mr. Whiting graduated in June 1957 from the University of Idaho with an M.S. degree in mining engineering.

Carroll S. Carter is now an industrial specialist with the Small Busi-

Blending . . .

Ore blending is particularly important in some uranium concentration. Multiple storage and conveying designed and built by Stearns-Roger has met the requirements of this southwestern producer. For materials handling, as for other important operations in the processing of metallic or non-metallic ores, rely on the complete services of Stearns-Roger for design, engineering, fabrication or field erection.

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ness Administration and is living in Louisville. He had been a lieutenant colonel in the U. S. Army, Corps of Engineers, in Washington, D. C.

J. A. Mecia and **C. W. Robinson** have been elected vice presidents of Utah Construction Co., Salt Lake City. Formerly manager of mines, Mr. Mecia will continue to direct the company's mining activities in the U. S. He is also vice president and director of Lucky Mc Uranium Corp. He resides in Los Altos, Calif. Mr. Robinson, formerly assistant secretary and assistant treasurer, is also vice president of Marcona Mining Co., Cia San Juan, and Ocean Services Inc. He is a resident of San Francisco.

James H. Jensen, formerly manager, plant engineering, Trona plant, American Potash & Chemical Co., has joined Western-Knapp Engineering Co., San Francisco.

R. K. DUEY

Robert K. Duey has been appointed Washington, D. C., Maryland, and Pennsylvania structural engineering representative for Southern Lightweight Aggregate Corp., Richmond, Va. Formerly chief engineer for the company, Mr. Duey will make his headquarters at Gaithersburgh, Md.

John A. Reeves, formerly mining supervisor with Monsanto Chemical Co., has joined Mid-Continent Coal and Coke Co. as manager of mines.

Thomas F. Edson, who had been a consulting engineer, has joined the staff of General Aniline & Film Corp. as plant manager.

Thomas A. Copeland is now associated with Comstock Oil Co., Austin, Texas, as manager. He had been plant manager for Eagle Picher Co.

Donald B. Buddecke is now explosives representative in the Four Corners area for Atlas Powder Co. He is a recent graduate as mining engineer of Texas Western College.

George F. Weaton, Jr., mine superintendent, St. Joseph Lead Co., Bonne Terre, Mo., has joined the School of Mines, University of Minnesota, Minneapolis, as a research associate.

J. C. PARLEE

Michael A. Price is now with Sevier Minerals Co., Kingman, Ariz., where he is engaged in mine examination and has been serving as mine foreman of the Gem Mine. Mr. Price had been connected with Wah Chang Mining Corp. as general superintendent for exploration, Copper King Mine, Bagdad, Ariz., and as exploration geologist.

New assistant vice presidents have been announced by the International Nickel Co. of Canada Ltd.: **Ralph H. Waddington,** also appointed general manager of the Ontario Div.; **James C. Parlee,** also named general manager of the Manitoba Div.; and **Richard A. Cabell** and **Paul Queneau** have been elected vice presidents of the U. S. subsidiary, The International Nickel Co. Inc.

John W. Miley, formerly shift boss, Homestake Mining Co., is now associated with Benguet Consolidated Inc., Baguio City, P. I., as foreman.

Robert E. Schaaf, mine geologist for The Anaconda Co., became associated in October 1957 with The Anaconda Co. (Canada) Ltd. as an exploration geologist.

Several personal changes have been made by United States Potash Co., a division of the U. S. Borax and Chemical Corp. **John G. Blanchard** has been transferred from chief clerk in the mine office to the accounting department in the Carlsbad office. **Robert T. Hayes** and **Pat L. Dyer** have been promoted from accounting clerk in the mine office to chief clerk and from journeyman electrician at the mine to face boss, respectively.

W. R. Swiler who has been district manager for Joy Manufacturing Co. at the Duluth Branch, has been transferred as district manager to Salt Lake City Branch.

Charles R. Kuzell has retired as vice president in charge of western activities for Phelps Dodge Corp. Mr. Kuzell has been associated with Phelps Dodge since 1935, first as manager of the Verde Branch, then as director of labor relations and consulting metallurgist at the company's office in Douglas, Ariz. He became general manager in 1952 and vice president in 1955. Mr. Kuzell will continue as a director of the corporation and will also serve in a consulting capacity. Long a member of AIME, he is now a Director and in 1956 was honored with the James Douglas Gold Medal for distinguished achievement in nonferrous metallurgy. Mr. Kuzell will be succeeded as vice president in charge of western activities by **Walter C. Lawson,** also named a director, who has been serving Phelps Dodge as general manager. Mr. Lawson is a mining engineer with long experience in the management of Phelps Dodge properties in Arizona, as general superintendent of its Morenci branch and manager of the New Cornelia branch. Prior to becoming general manager in 1955 he was assistant to the vice president of the corporation in charge of western activities.

Murl H. Gidel retired in January as assistant chief geologist for the Anaconda Co., Butte, Mont. He has been a member of the company's geological staff for 45 years and since 1936 he has been assistant chief geologist for North America.

R. Lee-Aston has left Tennessee Copper Co. and is now in the consulting business with his own firm, Mineral Drilling Service, Chattanooga, Tenn. His company specializes in core drilling and geological and mining consulting work.

C. M. F. PETERS

Chester M. F. Peters, consulting geological engineer, recently completed a 2-month's assignment examining coal, gold, and antimony in Bocas del Toro Province, Panama, as well as deposits in Costa Rica and Nicaragua.

Frederick C. Jaccard has retired from active service with The Anaconda Co., Butte, Mont. Mr. Jaccard

was instrumental in supervising installation of many of Butte's electric mine hoists, directed some of the preliminary work on Anaconda's famed Big Stack, and was in charge of the construction of the zinc plant at Great Falls. His official position with the company was mechanical superintendent, a position in which he is succeeded by **George H. Lilly,** who had been assistant mechanical superintendent. Other changes announced by Anaconda are: **Frank E. Ralph,** construction superintendent, to assistant mechanical superintendent; **Paul M. Young,** construction engineer, to mechanical superintendent; **William C. Norem,** construction foreman, to construction superintendent; **Joseph E. Ogle,** master mechanic, to superintendent of maintenance; **Warren L. Blake,** garage foreman, to automotive superintendent; and **Marcus E. McCanna,** design engineer, to chief draftsman.

R. E. Benedict has retired after 41½ years of service with Sullivan Machinery Co. and Joy Manufacturing Co. Mr. Benedict, whose assignments for the company took him to Spokane, San Francisco, Pittsburgh, Chicago, and South America, will continue to reside in Lima, Peru.

E. K. Barnes has been elected president of the Northwest Mining Assn. Mr. Barnes is a banker and mining man in Spokane. He succeeds **Karl W. Jasper,** Grandview Mines' president.

Morley Romanuck, geologist, formerly associated with the Quebec Cartier Mining Co. Ltd., Quebec, is now with W. S. Moore Co., Duluth.

J. R. Walker, Jr., is now vice president and controller of Kaiser Steel Corp. at Oakland, Calif., and **Ernest L. Ilsley,** previously fabricating division manager has been named vice president.

Walter R. Landwehr, chief geologist and acting manager of the western mining department of American Smelting & Refining Co., Salt Lake City, has retired from active service with the company. A native of Boone, Iowa, Dr. Landwehr studied mining at Oregon State College, Montana School of Mines, and Stanford University. He also did graduate work at the University of Wisconsin and received his Ph.D. degree in geology from Stanford. He joined American Smelting and Refining in 1931 as a geologist. During his years with Asarco, Dr. Landwehr was largely responsible for the geological work and development of the important lead-zinc properties in the Leadville district of Colorado and he also set in motion the exploration program for disseminated copper in the Pima area of Arizona. He is a director of the United Park City Mines Co. and a former director of the old Silver King Coalition Mines Co.

W. Aubrey Smith, general manager, has been elected a vice president of Southwest Potash Corp., Carlsbad, N. M. **V. A. Zandon** has been promoted to general manager from his position as assistant general manager. **John Sowers,** formerly mine superintendent, has been promoted to general superintendent at the Southwest property.

Charles R. Cox, president of Kennecott Copper Corp., has been honored by *Forbes Magazine* as one of "America's 50 foremost businessmen." The awards resulted from a poll of the nearly 250,000 readers of the magazine and assistance from the Nation's most respected business associations. Each of the 50 executives honored received a medal and an individual citation.

Richard O. Marsten, formerly shift boss of Wah Chang Mining Corp., has become engineer and assistant to superintendent of Edna Coal Co., Colorado.

H. G. Schuring is now mill superintendent for Neptune Gold Mining Co., Managua, Nicaragua. He had been mill superintendent for Atlas Consolidated Mining & Development Co.

Maurice A. Enright, a graduate of New Mexico School of Mines, has

ROUND BLAST HOLES!

Work Wonders...

yours only with
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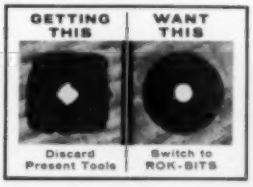

Large or small hole drilling, we have the bits for them all.

BRUNNER & LAY carbide Rok-Bits drill clean, ROUND Blast holes. Easy-to-load holes that need not be blown before loading. Rods pull easily. Rounds go in fast. Tonnage mounts. If you haven't used Brunner & Lay Rok-Bits on a test drill job—do it soon. Call our nearest plant. Brunner & Lay, Inc., 9300 King St., Franklin Park, Ill. Plants and warehouses: Philadelphia, Asheville, Birmingham, Dallas, Denver, Los Angeles, Portland, Ore., Montreal.

Brunner & Lay carbide Rok-Bits in these body types—cross, chisel, "X", cutaway, taper socket. Furnished in standard wagon drill and hand held drill threads—1000, 700, 600, 400, 200 and J-7.50 threads. Bit sizes up to 6½" in our Hole-Master. Write for New catalog #756.

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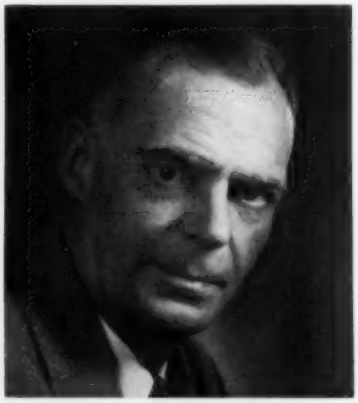
CARBIDE ROK-BITS • INTRA-SET STEEL • DRILL RODS • COUPLINGS, ADAPTERS & EXTENSION STEEL

joined San Manuel Copper Corp., San Manuel, Ariz., as mine engineer.

Charles David Mann has returned to St. Joseph Lead Co., Bonne Terre, Mo., as mining engineer after service with the U. S. Army.



L. T. BROWN

Leroy T. Brown is in Tinaquillo, Cojedes, Venezuela, where he is general manager and director of AMVECO, C. A., the asbestos mining and milling company of the Asbestos Div. of World Commerce Corp. S.A.

Robert G. Woolery, mining engineer-metallurgist for Union Carbide Nuclear Co., has been transferred to the new laboratory at Sterling Forest, N. Y. The research laboratory is a joint venture with Union Carbide Ore Co. Both companies are subsidiaries of the Union Carbide Corp.

George E. Aiken, former metallurgist for American Cyanamid Co., is now general supervisor—production for Orinoco Mining Co.

Several staff changes have been announced by The New Jersey Zinc Co. **W. L. Albers,** superintendent of the Austinville, Va., operation, is now general superintendent for Virginia. **Johnson Crawford,** superintendent for Tennessee, became general superintendent for Tennessee with his headquarters at Jefferson City. **C. G. Morgenstern,** assistant superintendent of the Austinville, Va., operation, became superintendent. **R. E. Radabaugh,** assistant to the western manager of mines, became assistant manager of exploration at Grand Junction, Colo. **F. H. Main,** assistant superintendent of Tennessee, is assistant manager of exploration with headquarters in New York.

Charles B. Pope has become assistant office engineer for Southern Peru Copper Corp., Tacna, Peru. He had been mining engineer for American Smelting & Refining Co., and assisted in the design of proposed Asarco East Pima pit near Tucson, Ariz.

Edgar P. Dunlaevy, vice president, has been elected executive vice president of Phelps Dodge Copper Products Corp. and **S. Allan Jacobs,** also vice president, has been named president of the company's Inca Manufacturing Div. in Fort Wayne, Ind.

Menelaos D. Hassialis, professor of mineral engineering and executive officer of Columbia University's School of Mines, received the *Great Teacher Award* of the University's Society of Older Graduates. Also honored with the award was Charles W. Everett, chairman of Columbia College's English Dept. Professor Hassialis is a 1931 graduate of Columbia College and did research work for Columbia University from 1934 to 1937. He joined the faculty of the School of Mines in 1937. The citation, which accompanied the award, read, in part, ". . . a teacher of distinction who possesses the attributes of personal warmth and common touch and the ability to elucidate clearly and precisely the many complex principles and problems of science that appear to the student at the onset as being completely without reason and without hope of understanding."

F. A. WARDLAW, JR.

Retirements recently announced by the Anaconda Co. include **Frank A. Wardlaw, Jr., James J. Lillie,** and **Fred W. Bellinger.** Mr. Wardlaw, who has been general manager of International Smelting and Refining Co., Salt Lake City, an Anaconda subsidiary, has been associated with the company for 34 years. Mr. Lillie, who has served in mine management capacities and Anaconda operations for many years, has been assistant to the general manager, International Smelting & Refining Co., Salt Lake City. Mr. Bellinger, who has been general manager of the Butte, Anaconda & Pacific Railway, has been with the road since 1913.

J. J. LILLIE

C. E. LACY

Chancelor E. Lacy, who joined Hardinge Co. Inc., in 1957 as manager of engineering service, has been appointed manager of the engineering dept. supervisor to assist Mr. Lacy. **Walter H. Glomb,** formerly chief engineer, has retired.

A number of personnel changes have been announced by American Smelting & Refining Co., Salt Lake City. **J. F. Frost,** who joined the company in 1925 at the Hayden, Ariz., plant and most recently has been a mining engineer with the Western Mining Dept., has been named manager of the department in Salt Lake City. **W. J. Nock,** who has been serving as assistant general manager of the Mexican Mining Dept. at El Paso, Texas, has been named general manager of the department. He replaces **C. F. Jordan,** who has retired. **J. G. Urquhart** has been appointed assistant manager of the Mexican Mining Dept., and will move to El Paso from Parral, Mexico, where he has been acting superintendent. He is replaced in Mexico by **C. W. Campbell** who, as superintendent of mining projects, will make his headquarters in Mexico City. **Samuel Neiman** retired in December. A veteran of over 40 years' service with the company, he was most recently associated with the Federated Metals Div. at the St. Louis plant. **A. J. Yeager** has been made assistant general manager of the Mexican Mining Dept.

W. H. Lesser, of Scranton, Pa., has been awarded an honorary life membership in ASME. Mr. Lesser, whose specialty is mechanical and electrical engineering, has spent his entire professional career in the engineering,

development, and management of anthracite mines.

Clinton H. Hoch has been appointed staff representative for mining, coal mining, and cement, quarry, and mineral aggregates sections of the National Safety Council, Chicago. Mr. Hoch replaces **G. G. Grieve,** who has been named director of the Council's Labor Div. Mr. Hoch has been associated with Pennsylvania mining firms, was safety instructor with the Pennsylvania Dept. of Mines, and has seen service with a Chicago consulting firm, for whom he spent a year in Turkey as safety engineer and nine months in Brazil as part of a three-man team which mechanized a coal mine as a model for the coal commission of Brazil.

Harry C. Swanson has been promoted to general superintendent, Michigan Mines for The Cleveland-Cliffs Iron Co., Ishpeming, Mich. Mr. Swanson, who is a native of the Marquette range, has been with CCI since 1943.

Ted C. Mathews and **James W. Dalton** are the principals in a new company, Exploration Services Inc., Fairbanks, Alaska. The concern, a consulting service, was formed for the purpose of aiding in the development of Alaska's petroleum and mineral resources. Both Messrs. Mathews and Dalton are graduate mining engineers from the University of Alaska and have been active in exploration for petroleum, minerals, and in construction for the past 20 years.

Three executives have been promoted by Bituminous Coal Research Inc., Pittsburgh. **Harold J. Rose** is vice president and consultant, **J. R. Garvey** is director of research, and **John W. Igoe** is director of administration. Dr. Rose joined the organization in 1944 as vice president and director of research; Mr. Garvey has been assistant director of research in charge of the Columbus, Ohio, laboratory; and Mr. Igoe has been assistant director of administration.

Gerald C. Nalon is sales representative for the mining sales section, Metallurgical Products Dept., General Electric Co., Detroit. He joined the company in 1950 in the chemical and metallurgical training program. Mr. Nalon will be responsible for the sale of such mining products as hard metals for percussive and rotary applications.

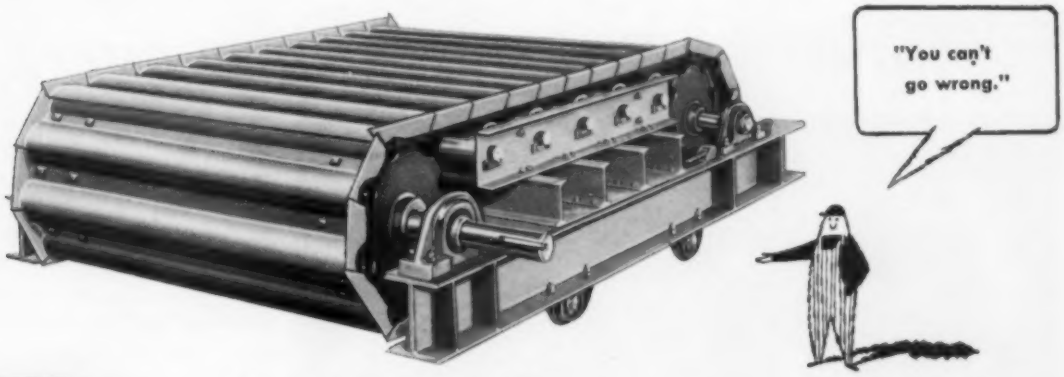
J. E. Hughes, vice president of Henry J. Kaiser Co., has been appointed assistant general manager of the Kaiser Engineers Div., Oakland, Calif.

C. G. Sears is sales manager for Pioneer Engineering, a division of Poor & Co., Minneapolis. Mr. Sears joined Pioneer in 1945.

C. G. SEARS

Marion Power Shovel Co., Marion, Ohio, has named **Mike Geller** as assistant sales manager and **Bob Falck** as western regional sales manager. Mr. Geller joined the Marion Sales staff in 1955 and most recently served as district manager in the company's eastern sales district. Recently western district sales manager, Mr. Falck joined the company in 1955.

Wesley Davenport, vice president of long range planning for E. J. Long-



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Every part of a Rex Feeder is designed to meet your toughest feeding requirements. Rugged frames, rugged components and husky engineering design are combined to give you long life with minimum down time. For feeders, elevators, idlers, pulleys, see your CHAIN Belt Sales Engineer. CHAIN Belt Company, 4794 West Greenfield Avenue, Milwaukee 1, Wisconsin.

CHAIN BELT COMPANY

Milwaukee 1, Wisconsin

year Co., Minneapolis, retired in December after 28 years' service with the company. He joined Longyear in 1929 and was, successively, chief accountant, treasurer, member of the board of directors, and general manager, prior to his appointment as vice president in 1955. Mr. Davenport assumed the job of directing long range planning in 1957.

L. Z. BUDZEN

Leonard Z. Budzen is manager of mining sales, metallurgical products department, General Electric Co., Detroit. A graduate of the University of Michigan, he joined General Electric in 1941. Most recently, he has been a mining sales specialist.

Myron A. Kendall, board chairman of Stephens-Adamson Manufacturing Co., dean of conveyor engineers, has been honored by the ASME with a *Fellow Award*. Mr. Kendall, a graduate of the University of Illinois, has also served as draftsman, chief draftman, and chief engineer for Stephens-Adamson.

F. W. Davis, who has been associated with American Cyanamid Co., at the Latrobe, Pa., plant, has been named assistant manager of manufacturing for explosives of the Organic Chemicals Div. of the company. Mr. Davis, who has been serving as assistant manager of the Explosives Dept., is in charge of all manufacturing activities at Cyanamid explosives plants in Latrobe and New Castle, Pa.; Grafton, Ill.; and Springville, Utah.

Three divisional vice presidents have been appointed by Pacific Coast Borax Co., a division of U. S. Borax & Chemical Corp. **L. L. Fusby** is vice president—production, **R. W. Hinchman** is vice president—sales, and **M. H. Pickard** is vice president—market research and product development. Messrs. Hinchman and Pickard will make their headquarters in New York and Mr. Fusby in Los Angeles.

A number of personnel changes have been announced by Anaconda Sales Co., a subsidiary of The Anaconda

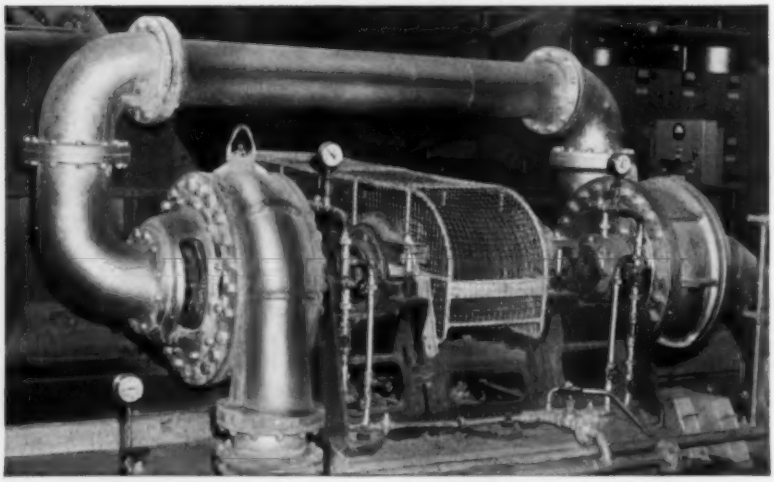
H. M. WEED

Co. **Herbert M. Weed** has been named vice president. Three other officers have retired—**W. E. Kennedy,** executive vice president; **Clarence Glass,** vice president; and **John A. O'Brien,** assistant secretary. These changes also apply to Anaconda Export Co., subsidiary of Anaconda Sales Co.

John A. Wettergreen has been named manufacturing vice president and general works manager of Marion Power Shovel Co., a division of Universal Marion Corp., Marion, Ohio. Mr. Wettergreen was most recently associated with Bucyrus-Erie Co., South Milwaukee, where he served as works manager, general works

handling the slurry in a hurry

for the South African Electricity Supply Commission . . .



Operating as boosters, these 2-stage Linatex pumps have a capacity of 1,800 gallons of slurry per minute. The pumps were supplied to the South African Electricity Supply Commission to meet the demand for installations that could handle large quantities of boiler dust slurry without wearing out. With a first stage intake of 50 lbs. per square inch and a second stage discharge of 160 lbs. per square inch, the pumps have proved—once again—the operating efficiency and long-lasting qualities of the Linatex pump.

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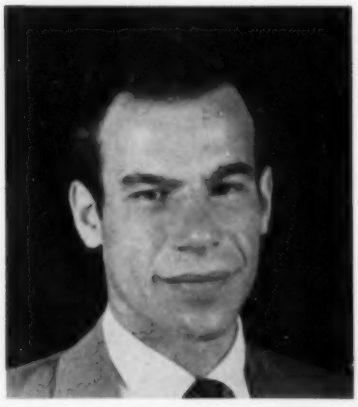
GI297/P24

manager, and vice president in charge of manufacturing.

Harry F. McFarland, consulting mining engineer, recently flew from Denver to Rangoon, Burma, to take up his duties of teaching mine engineering for the International Labor Office (UN) in the Burma Technical Inst. A graduate of the Colorado School of Mines in 1932, Mr. McFarland has been associated with Homestake Mining Co.; Cerro de Pasco Copper Corp., Peru; West Rand Mines Ltd., South Africa; and several oil and mining interests whom he served as a consultant.

Henry Beaufort Somerset has been elected president of the Australasian Inst. of Mining and Metallurgy for 1958. Mr. Somerset is managing director of Associated Pulp and Paper Mills Ltd., chairman of directors, Australian Titan Products Pty. Ltd., vice chairman of the directors, Goliath Portland Cement Co. Ltd., director of Electrolytic Zinc Co. of Australasia Ltd., and a director of Humes Ltd.

Charles P. Seel, formerly chief geologist for San Luis Mining Co., Durango, Mexico, is now associated, as consulting and chief geologist, with Hoagland & Dodge Drilling Co. Inc., Tucson, Ariz.



C. P. SEEL

James D. Moore, chief process engineer, has become production manager of Vitro Uranium Co. He is responsible for all plant operation, engineering and maintenance, and process research and development. He joined the company in Salt Lake City in 1951.

A. G. Kirkland, Salt Lake City, has been appointed manager of mines for Howe Sound Co. Mr. Kirkland, a native of Toronto, and a graduate of Queens University, is a former manager of mines for western operations of U. S. Smelting, Refining and Mining Co., Salt Lake City.

P. A. Laylander, a consulting geologist, has become associated with California Perlite Corp. as manager of the mine and mill which is situat-

Interior of a Hardinge 11½′ x 12′ Rod Mill with 85-ton rod load, 1000 horsepower.

Hardinge

ROD MILLS

Sizes range from 2′ to 11½′ shell diameter and up to 1000 horsepower.

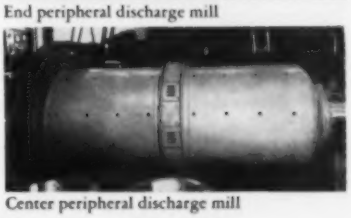
Types include trunnion overflow and peripheral discharge for both wet and dry grinding.

Applications include both open and closed circuit arrangements for ores, aggregates, concrete sand, cokes, and abrasives.

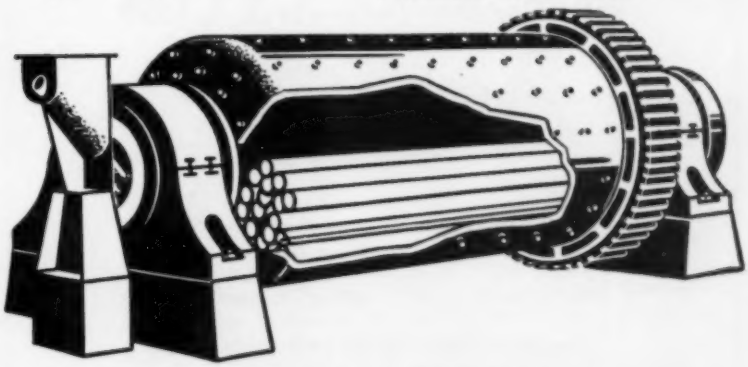
Complete specifications on request. Bulletin 25-C-2

Trunnion overflow mill

End peripheral discharge mill



Center peripheral discharge mill



Cutaway view of Hardinge Rod Mill

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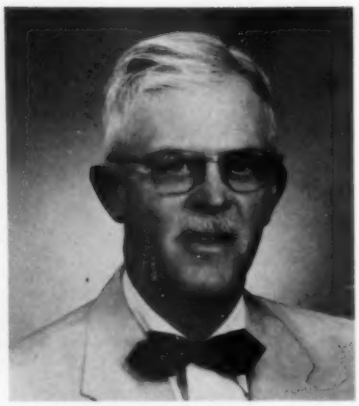
ed east of Barstow, Calif. Mr. Laylander will continue his geological consulting work, specializing in photogeology, making and analyzing stereoscopic color aerial photographs of mining districts.

R. H. Nagell, who received his Ph.D. in geology from Stanford University, Stanford, Calif., and who had been associated as geologist with Cerro de Pasco Corp. and Minera Guprum S.A., Mexico, has become chief geologist for ICOMI S.A. He will be in charge of the Dept. of Geology at the Serra do Navio manganese operation in Brazil.

W. D. McMillan has resigned after 17 years of service with the Dept. of the Interior, U. S. Bureau of Mines.



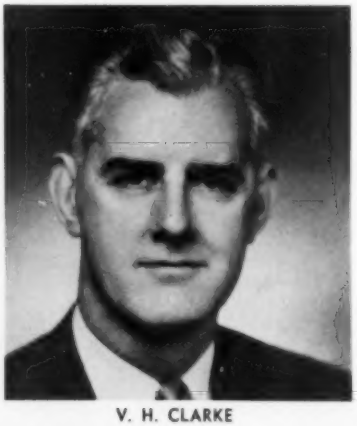
W. D. McMILLAN

Mr. McMillan, whose specialty is mining, engineering and geology, has also had 26 years of experience in private industry on four continents. His work has consisted principally of examination, evaluation, exploration, and operation of mines or prospects containing base and precious metals, ferroalloys, uranium, and nonmetallics, including diamonds. He is now associated with two Denver firms as a consultant engineer-geologist.

P. D. I. HONEYMAN

A number of personnel changes have taken place at Inspiration Consolidated Copper Co. **P. D. I. Honeyman** has been elected president. He had been a director and vice president and general manager. **William Wraith, Jr.,** has been elected a director. **H. Myles Jacob** has been elected executive vice president; **H. Carroll Weed,** general manager and **Carl G. Stunz,** assistant general manager of Arizona operations; and **Edward F. Wendt,** secretary-treasurer.

Vinton Clarke has resigned as vice president in charge of mining and exploration of Howe Sound Co., Salt Lake City, to join the mining, geological, and metallurgical consulting firm of Behre Dolbear & Co. Inc., New York. Mr. Clarke had been associated with Howe Sound for over 20 years.



V. H. CLARKE

John H. Jett has been appointed vice president and general manager of

AIME

Student Prize Paper Contest

(Undergraduate and Graduate Divisions)

Entry Deadline Date—Sept. 1, 1958

Topics: Mining, Metallurgy, and Petroleum

Exploration • Production • Engineering • Research

Limited to AIME Junior Members and Student Members

Contact your Student Chapter, Chapter Counselor,
Section in your area, or Prof. John Butler,
University of Nevada, Reno, Nevada.

Vulcan Iron Works Co., Denver. Mr. Jett, who has been serving as acting general manager, joined Vulcan as a sales engineer in 1954. Prior to that time, he had been associated with the mining division of the AEC. **C. W. Hawn** recently joined Vulcan as a sales engineer.

Raymond Mancha, who has been ventilation vice president of Joy Manufacturing Co., Pittsburgh, is retiring in order to find time for personal interests and study, including work on advanced concepts of mine and industrial ventilation principles. Mr. Mancha, a recognized authority particularly on mine ventilation and a prolific contributor to the literature of the field, is a graduate of Massachusetts Institute of Technology.

OBITUARIES

Paul Dyer Merica
An Appreciation By
John F. Thompson

Space limitations make it difficult to give a completely rounded picture of Paul Dyer Merica (Honorary Member 1918)—teacher, metallurgist, scientist, and business executive. From a purely professional standpoint, one is tempted to cite his many scientific achievements as exemplified by some 60 published articles and the numerous patents in which he was either the sole or joint inventor. From an industrial standpoint, much could be said about him as a former president of The International Nickel Co. of Canada Ltd. In this position he brought all of his great abilities to bear on the various problems connected with the production research and commercial distribution of copper, nickel, and other nonferrous metals.

Dr. Merica's life was passed in many parts of the world. Born in Warsaw, Ind., he was educated first at DePauw University, and later at the University of Wisconsin. Prior to receiving his doctorate from the University of Berlin, he entered the teaching profession at a time when his father was president of the University of Wyoming. He taught physics at the University of Wisconsin and then spent two years on the faculty of the Chekiang Provincial College in Hangchow, China. In 1914 he joined the U. S. Bureau of Standards at Washington. While there he was instrumental in the discovery of the new and fundamental metallurgical concept now known as *precipitation hardening*, which has had a profound influence on both theoretical and practical metallurgy. After five years with the Bureau of Standards, Dr. Merica came to the International Nickel Co. where he first served in the Research Dept., then as director of research, and successively as executive vice president and president. During this period he spent a portion of each year in Europe where he became intimately concerned with European research, especially on nickel and its alloys. His acquaintances there were wide and his relations with European scientists, having started with their respect for his professional work, developed over the years into many close friendships.

Dr. Merica's professional work was publicly recognized by honorary degrees from DePauw University, Lehigh University, and Stevens Institute of Technology, and the awarding to him of the following medals: AIME James Douglas Medal (1929), The John Fritz Medal (1938), the Institute of Metals Medal (1941), the Franklin Institute Medal (1942), and ASM Gold Medal (1951).

Correction

Daniel M. Coxe was incorrectly listed on the Necrology list published in May 1957 and in *Obituaries* in August 1957 MINING ENGINEERING. Mr. Coxe is still very active in coal mining affairs. He is associated with the estate of Tench Coxe, deceased, the owner of the Buck Mt. property, and the estate of Charles S. Coxe, deceased, Drifton, Luzerne Cty., Pennsylvania.

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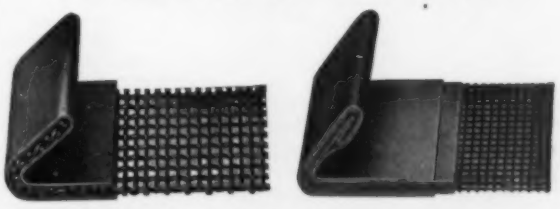
for All Makes
of Screening Machines!



Screen sections of Tyler Woven Wire are fabricated for all makes of vibrating screens in any mesh or metal. They are made up with hook-strip or bent-edge construction to suit the machine on which they are to be used.

Tyler rugged, accurately-applied hook-strips make possible stretching and maintaining the screens at drum-head tension, which is essential for successful screening and long screen life.

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After he retired from the presidency of The International Nickel Co., Dr. Merica continued to serve the company on important projects and as a consultant. His mature judgment, coupled with his experience in all phases of the company's business, was sought by his associates on the various problems which arise in a wide-flung metal business.

By his friends and associates in the Institute, Dr. Merica will perhaps be remembered as one whose long services to it were eminently recognized through his election to Honorary Membership. But to many who knew him personally he will always be best remembered for his warm, fine human qualities which transcended even his great technical achievements.

Herbert A. Sawin

An Appreciation By
C. M. Romanowitz

Herbert A. Sawin (Member 1935), sales engineer for the Yuba Manufacturing Co., died in an Oakland, Calif., hospital on Dec. 2, 1957, after a long illness. H. A. Sawin was born on Mar. 5, 1894, in Springfield, Mass., receiving early engineering training and experience at the Cramp Shipyard in Philadelphia during World War I. He joined the Yuba Manufacturing Co. in 1922 and remained with them for the following 35 years until his death.

Mr. Sawin worked in various departments of the company, and for the last 25 years was in the Sales Dept. where his final title was assistant director of dredge sales.

Active in Kiwanis, Mr. Sawin was a past-president of the Engineers' Club of San Francisco, a member of ASME, and the American Ordnance Assn.

He was widely known for his activities in AIME and was a past-chairman of the San Francisco Local Section. Both in AIME Section activities and personally he was noted for his kindness and interest to young engineers in the local colleges of the Bay area. Many engineers who had not been heard of for years returned to call at the Yuba office to thank Herb for the suggestions and start that he had given them at the time they left college. Future generations of graduates will deeply miss his kind and well informed interest and guidance.

He is survived by his wife, Mrs. Melba Sawin of Berkeley, Calif.; a daughter, Mrs. Peter Overmire; and two grandchildren of Orinda, Calif.

George W. Baekeland (Member 1919) died recently. Mr. Baekeland had been associated with Electro Metallurgical Co., advertising department, in New York. Born in Yonkers, N. Y., in 1895, he attended Cornell University and graduated from the Colorado School of Mines with an E.M. degree. Mr. Baekeland's early professional experience was in mine examination and geological exploration. He did geological exploration work in Africa and Europe and was associated with the Standard Oil Co. of New Jersey in mining and metallurgical engineering. Mr. Baekeland began his long association with Union Carbide Corp. in 1923 when he became an engineer for Bakelite Corp.

George L. Collord (Legion of Honor Member 1901) died in Pittsburgh in November 1957. A retired blast furnace authority and business executive, Mr. Collord was born in 1876 in Pittsburgh and graduated from Princeton University with a B.S. degree. He spent most of his professional career with the Shenango Furnace Co. which he joined shortly after graduation from college as a chemist. Mr. Collord became blast furnace superintendent for the company; after brief periods with the Carnegie Steel Co. and Tennessee Steel and Iron Co. he rejoined Shenango as blast furnace manager. He became vice president-general manager of the Shenango Furnace Co., the position he held at the time of his retirement. A long time resident of Pittsburgh, he was active in civic affairs, serving as a director of the Allegheny General Hospital, the Carnegie Hero Fund, and a trustee and vice president of the Dollar Savings Bank. Mr. Collord had also been associated closely with the William Penn Snyder interests.

John Carl Detweiler (Member 1951) died in Jacksonville, Fla., on Nov. 15, 1957. At the time of his death, he was technical superintendent of the Trail Ridge and Highland Plants near Starke, Fla., for Humphreys Gold Corp., engaged in titanium mining operations. A graduate of the University of Denver, Mr. Detweiler was born in Los Angeles in 1905. Prior to joining Humphreys Gold in 1945 he had been associated with Charles O. Parker and Co. as a chemist engaged in metallurgical analysis and with Denver Equipment Co. as a test engineer engaged in ore testing.

John Drotar, Jr. (Member 1956) was killed in an automobile accident on Nov. 16, 1957. Born in Barnesboro, Pa., in 1934, he attended local schools and graduated from Pennsylvania State University in 1956 with a B.S. degree.

Harold L. Gardner (Member 1948) died in Dallas on Oct. 22, 1957. Born in Springfield, Mo., in 1904, he graduated from Colorado School of Mines with an E.M. degree. Shortly after graduation Mr. Gardner joined Braden Copper Co., Rancagua, Chile as level boss and foreman. He later joined Cerro de Pasco Copper Corp. in Peru as a mine engineer. Prior to returning to Cerro de Pasco Copper Corp. as shaft boss and foreman, Mr. Gardner was associated with Peru Mining Co., Hanover, N.M., as assistant mine superintendent and Shenandoah-Dives Mining Co., Silverton, Colo. Leaving Peru in 1936, he joined New York and Honduras Rosario Mining Co., San Juancito, Honduras, as general mine foreman. Mr. Gardner was associated with Benguet Consolidated Mining Co., Manila, P. I., as foreman, before joining International Minerals and Chemical Corp., Carlsbad, N. M., as mine engineer.

Robert H. Isenberg (Member 1954) died on Dec. 8, 1957, in Bellevue, Pa. At the time of his death he was plant metallurgist at the Monessen Plant, Pittsburgh Steel Co. Born in Monessen in 1909, he graduated from Allegheny College in 1932 and completed graduate work in Pennsylvania State extension courses in the University of Pittsburgh. Joining Pittsburgh Steel Co. in 1933, he performed metallurgical assignments in practically every steelmaking and processing unit of the Monessen Works. In addition to AIME, he was a member of ASM.

Augustine B. Kelley (Member 1934), member of the U.S. House of Representatives from Pennsylvania, died on Nov. 20, 1957, in Suburban Hospital, Bethesda, Md. Representative Kelley was born in New Baltimore, Pa., in 1883, attended Greensburg High School, and studied at the U.S. Military Academy at West Point, before leaving the Army for health reasons. Returning to Pennsylvania, he was associated with H. C. Frick Coke Co. and became its younger superintendent. Representative Kelley was connected with several mining properties and at the time of his election to Congress in 1940 was president and owner of the Mammoth Coal & Coke Co. During his long career in Congress, Mr. Kelley was a member of the House committee on education and labor, a member of the joint economic committee, and one of the House delegates to the International Labor Organization conferences in the 1940's. One of the many programs with which he was actively associated was that of increased benefits for disabled war veterans. A member of numerous professional organizations, including the American Mining Congress and AIME, Mr. Kelley was also active in many civic and religious affairs, particularly in his native state of Pennsylvania.

William L. Kleitz (Member 1938) died on Nov. 19, 1957. At the time of his death he was associated with the Guaranty Trust Co. of New York. A graduate of Cornell University with an A.B. degree, Mr. Kleitz

was born in Highland Falls, N. Y., in 1894. During his long career with Guaranty Trust Co., he was, successively, clerk, assistant treasurer, assistant vice president, and vice president. He was actively associated with mining accounts for the bank.

Ralph E. Larry (Member 1921) died in Pittsburgh on Aug. 31, 1957. Mr. Larry, who during his professional career had been associated with the mining activities in Pennsylvania, was born in Providence in 1884 and attended Brown University. After brief periods with Stonega Coke & Coal Co. in Virginia and with Old Sterling Iron and Mining Co., Antwerp, N. Y., as pit boss in the iron ore shaft mine, he joined Colonial Iron Co., Middlesburg, Pa., as supervisor of ore mines and stone quarries. During part of his career, Mr. Larry operated ore mines on a self-employed basis in Pennsylvania. He later was associated with Michigan Limestone & Chemical Co., Rogers City, Mich. Returning to York, Pa., he was quarry general superintendent for J. E. Baker Co. before becoming a member of the staff of the Pittsburgh Limestone Co. During his years with Pittsburgh Limestone, he was, successively, superintendent at the Annandale Mines, Boyers, Pa., supervisor of operations and safety in Pittsburgh, and supervisor of industrial relations.

George C. McFadden (Member 1915), a principal and vice president of Paul Weir Co., died on Dec. 1, 1957, in Evanston, Ill. A native of Scotland in 1888, he came to the U.S. and attended schools in Danville, Ill. Mr. McFadden began his coal mining career in Danville and rose to positions as chief engineer and assistant vice president in charge of the countrywide operations of Peabody Coal Co. During his 18 years as a consultant with Paul Weir Co., he traveled extensively in the U.S., Turkey, Germany, and Great Britain. In addition to AIME, Mr. McFadden was a member of the American Mining Congress, the Coal Mining Inst. of America, and was a past-president of the Illinois Mining Inst.

John L. Ramsell (Member 1939), manager of Kerr-Addison Gold Mines Ltd., Toronto, died on Dec. 15, 1957. A native of Vancouver, he graduated from the University of British Columbia in 1925 with a B.A.Sc. degree in geological engineering. Shortly after graduation Mr. Ramsell joined the staff of Britania Mines and continued with the company as chief engineer until 1927 when he joined the Exploration Dept. of Britannia. He attended the University of Wisconsin in 1928, taking graduate work in geology and mining. Prior to joining Kerr-Addison in 1946, he was associated with Howey Gold Mines and McKenzie Red Lake Mines. At Kerr-Addison, Mr. Ramsell was mine superintendent and became mine manager in 1955. He was a member of the CIM, past-president of the Mines Accident Prevention Assn. of Ontario, and president of the Ontario Mining Assn.

Thomas C. Shotwell (Rocky Mountain Member 1928), a resident of Maplewood, N. J., died on Dec. 13, 1957. Before moving to Maplewood he had been associated with H. L Horton & Co., N. Y.

Harold B. Smith (Member 1956), geologist in charge of the exploration department for Howe Sound Co., died in Salt Lake City recently. A native of Grand Forks, N. D., in 1906, he attended the University of Washington, graduating in 1928 with a B. S. degree. He later did graduate work at the University. After summer work with the Willow Creek Mines Inc., Wasilla, Alaska, he returned to the Yukon as sampler, assayer, and mill foreman for Treadwell Yukon Co. He later became superintendent for the company. Mr. Smith joined Howe Sound Co., Salt Lake City, as geologist in the Chelan Div. Named geologist in charge of the expanded exploration department in the Intermountain area, he had been instrumental in discovering and helping to develop the firm's cobalt properties at Cobalt, Idaho.

B. Helme Stockett (Member 1918), who has been general manager for Weston Dodson interests prior to his retirement in 1946, died on Dec 23, 1957, in Pottsville, Pa. Born in Bethlehem in 1888, he began his professional career as a mining engineer for Lehigh Coal and Navigation Co., Lansford, Pa., before joining Locust Mountain Coal Co., Shenandoah, a Weston Dodson & Co. Inc. interest, as superintendent and engineer in 1913. He was in charge of the development and operation of the Locust Mountain property until its exhaustion in 1933. An authority on stripping and a pioneer in the use and development of electric draglines for stripping work, Mr. Stockett pioneered in the development of the Chance cone method for preparing anthracite. In 1918 he became general superintendent of all anthracite operations of Weston Dodson & Co. and shortly afterward was also appointed general manager of bituminous properties.

William J. Swigert (Member 1956), who had been associated with The Anaconda Co. as mining engineer in the Exploration Div., died August 1957. Born in Challis, Idaho, in 1926, he graduated from the University of Idaho with a B.S. degree in mining engineering in 1953.

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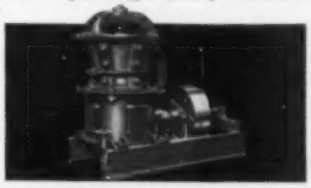
Sturtevant crushing and grinding machinery answers the long life top-load production problem for medium to small size plants. Many Sturtevants have been operating above rated capacities for more than 25 years, and *without a major repair.*

"Open-Door" design gives instant accessibility where needed — makes cleanouts, inspection and maintenance fast and easy. Machines may be set up in units to operate at equal quality and capacity.

Jaw Crushers — Produce coarse (5 in. largest model) to fine (⅛ in. smallest model). Eight models range from 2 x 6 in. jaw opening (lab model) to 12 x 26 in. Capacities to 30 tph. All except two smallest sizes operate on double cam principle — crush double per energy unit. *Request Bulletin No. 062.*



Rotary Fine Crusher — Reduce soft to medium hard 3 to 8 in. material down to ¼ to 1¼ in. sizes. Capacities up to 30 tph. Smallest model has 6 x 18 in. hopper opening; largest, 10 x 30 in. Non-clogging operation. Single handwheel regulates size. *Request Bulletin No. 063.*

Crushing Rolls — Reduce soft to hard 2 in. and smaller materials to from 12 to 20 mesh with minimum fines. Eight sizes, with rolls from 8 x 5 in. to 36 x 20 in.; rates to 87 tph. Three types — Balanced Rolls; Plain Balanced Rolls; Laboratory Rolls — all may be adjusted in operation. *Request Bulletin No. 065.*

Hammer Mills — Reduce to 20 mesh. Swing-Sledge Mills crush or shred medium hard material up to 70 tph. Hinged-Hammer Pulverizers crush or shred softer material at rates up to 30 tph. Four Swing-Sledge Mills with feed openings from 6 x 5 in. to 20 x 30½ in. Four Hinged-Hammer Pulverizers with feed openings from 12 x 12 in. to 12½ x 24 in. *Request Bulletin No. 084.*

**Reports Manager W. Carleton Merrill concerning Sturtevant Swing-Sledge Mill at James F. Morse Co., Boston.*

STURTEVANT
MILL COMPANY
154 Clayton St., Boston 22, Mass.

Prior to joining The Anaconda Co., Mr. Swigert had been associated with Bayhorse Mines Inc.

S. C. Yule (Member 1950) died on Dec. 15, 1957. A native of Canada, he was born in Hagersville, Ont., Canada, in 1909 and graduated from Queens University with a degree in mining engineering. At the time of his death Mr. Yule was associated with Kerr-Addison Gold Mines Ltd. which he joined in 1945. He began his career in mining with Noranda Mines Ltd. Later he was associated with Bussierre Mining Co. as shift boss and Perron Gold Mines as superintendent before joining Kerr-Addison as shift boss. At Kerr-Addison, Mr. Yule was mine captain, assistant mine superintendent, and mine superintendent. During World War II he served with the Royal Canadian Air Force.

Necrology

Date Elected	Name	Date of Death
1905	Edgar C. Agabeg Legion of Honor	Unknown
1935	Charles H. Bowen	Jan. 4, 1958
1948	Lawrence C. Flickinger	July 17, 1957
1951	James D. Francis	Jan. 8, 1958
1952	F. Hewett	Dec. 27, 1957
1916	Charles Hoyle	Dec. 28, 1957
1953	Peyton L. Mitchell	Oct. 26, 1957
1955	T. V. Stephens	Apr. 17, 1957
1948	Roy J. Tribbey, Jr.	September 1957
1902	W. R. Whitney Legion of Honor	Jan. 9, 1958

MEMBERSHIP

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Continued on Page 414

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Continued from Page 413

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